Supreme Court of the United States.

OCTOBER TERM, 1886.

No. 668.

THE AMERICAN BELL TELEPHONE CO. ET AL.

APPELLANTS,

v.

THE MOLECULAR TELEPHONE CO. ET AL.

CROSS APPEAL IN CASE No. 667 FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

BRIEF FOR AMERICAN BELL TELEPHONE CO. ET AL.

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THE TELEPHONE APPEALS.

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CROSS-APPEAL IN CASE NO. 667 FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

BRIEF FOR THE AMERICAN BELL TELEPHONE COMPANY ET AL., *APPELLANTS.*

This is a cross-appeal in the same case as No. 667.

In this case the court below decided that claim 5 of Mr. Bell's *second* patent No. 186,787, of January 30, 1877, is bad. The whole patent is for improvements in the structure of the speaking telephone of his first patent. The claim is:

"The formation in an electric telephone, such as is herein shown and described, of a magnet with a coil upon the end or ends of the magnet nearest to the plate."

This claim had been discussed in the evidence in the Dowd suit, and had been sustained *sub silentio*, in all the cases. The discussion under the first patent had been laborious and protracted and nothing was said about this claim. Judge Wallace got the notion that it was a claim as for a new kind of magnet, in which case it would clearly be bad, because the magnet had long been known. Such a magnet formed a part of the Hughes printing telegraph described by Schellen, whose book was in evidence in the Dowd and all the subsequent cases. Judge Wallace, stating that the claim had not been argued, fell into an oversight and error about its purport, and held that the Hughes magnet was a clear anticipation. This decision was in June, 1885, and is here appealed from.

Subsequently, in December, 1885, on the hearing of the Overland case, it was pointed out to Judge Wallace that the claim was not for the magnet *per se* but for an improved form of telephone made by taking out the magnet shown in Bell's first patent, and putting in this one under circumstances which showed a good deal of boldness and originality. He at once perceived the misconception he had fallen into and sustained the claim as appears from his decree. (Overland, vi, 4178.)

The following is substantially the brief then presented to him:

Hughes, many years ago, invented a very ingenious printing telegraph. The plan was to have synchronously working clockwork at each end. When the key corresponding to a particular letter was pressed at the sending end, and the circuit closed, the current was used either to start or stop the clockwork, and, consequently, the letter which was at the proper place in the moving machine just at that instant was caused to operate and make a mark. The whole work at the receiving station was done by clockwork, driven by a weight, and the function of the electrical current was merely to pull a trigger, and start or stop that clockwork at the proper time. This is the apparatus which is described and shown in the Schellen book. In it Hughes employed the following device:

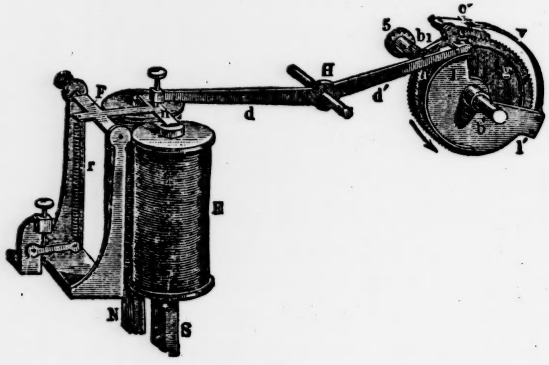

FIG. 375.

FIG. 376.

The horseshoe steel permanent magnet N S has mounted on each of its poles, N and S, a soft iron core, with a coil round it. The soft iron cores are not naturally magnetized, that is, they are neu-

tral; but by being placed in metallic contact with the poles of the permanent steel magnet which is permanently magnetized, these soft iron cores become for the time being magnetic by induction; and if a piece of soft iron, that is to say, an armature *n*, be placed in contact with the two upper ends of the cores of the coils E E, it will be held there by them by that magnetism. The soft iron armature *n* was laid by Hughes on top of the cores E E, with a retractile straining spring, shown as F and *r* in the drawing, tending to lift it away; but the strength of the spring was so graduated, by means of an adjusting screw, that it would not quite overcome the strength of the magnet. The armature was thus held, though with a nearly counterbalanced force, in contact with the poles of the two cores.

It is a fact in science that when, with such a contrivance, a current of electricity is passed through the coils which surround these two cores, it will, if it goes in one direction, increase the magnetism of the cores, making what is called the north pole more strongly north, and the south pole more strongly south. If, on the other hand, the current be passed in the reverse direction, it *tends* to make the north pole become south, and the south pole become north. Or, in other words, the magnetism which this latter current is disposed to make is opposed to that already existing in the magnet, and *tends* to neutralize it. If the current, therefore, which is to be used in this apparatus be sent always in what we may call the "*reverse*" direction, it will, each time it passes, *diminish* the normal magnetism of these cores, and consequently their power to hold the armature against the stress of the retractile spring.

Hughes employed a current which he always sent in the direction opposed to the permanent magnetism of this receiving magnet, and the forces and strains were so proportioned that when that demagnetizing current passed it weakened the magnetic force of the cores just so much that it was no longer able to overcome the retractile force of the spring, and the spring got the upper hand and pulled the armature away from the cores. That motion, through a system of leverages H, pulled a trigger and started or stopped some clockwork, a part of which is shown in the wheel at the middle of the cut. That was its whole operation.

The working of the magnet released the armature, but all its

motion was not only given to it by, but was *solely controlled* by, the spring and clockwork: the pull of the magnet and the variation in the currents did not in any way control the character of the movement.

The magnetic contrivance used by Hughes was, for reasons presently to be explained, very weak, and although he could thus enfeeble it enough to *release* the armature, he could not give it any strength which would pull the armature back; it must be brought back again in order that it might be ready to be released the next time, and in his machine it was brought back by clockwork. The operation of the magnetic contrivance at the receiving end of Hughes's printing telegraph was, that the demagnetizing current weakened the magnet enough to release the trigger, but no power existed by which either the magnet or the electricity could move the armature back again.

The absolute strength of the pull which can be exerted by a magnet when a current of electricity of a given strength is sent through the coils under circumstances which permit it to have its maximum effect, depends very much upon the size of the magnet; and, within practical limits, the larger the magnet the greater the weight which, when fully magnetized by a current, it can sustain; or in other words, the greater the force it can exert to pull an armature exposed to its influence.

The Hughes magnet, therefore, was, and this was a well-known fact about it, extremely weak in this respect; as a permanent magnet it would hold a certain amount, but a current sent around it in the *strengthening* direction would increase its magnetism very little, and therefore it could not be employed to move a soft iron armature by attracting it with any considerable effect. Hughes did not attempt to use it for that purpose, and for these reasons the magnet, although useful for the particular purpose for which he employed it, never went into practical use in telegraphs. It was a magnet certainly known in the arts from Hughes's use of it, and was used in his machine; but it was a magnet which had been found disadvantageous for practical use in any cases where it was necessary to move an armature by variations of magnetic force.

The instrument fig. 7 of Mr. Bell's first patent transmitted speech;

but its results were feeble, and he desired to increase them. Its results were due to motions which it imparted to a soft iron armature by alternately drawing it by means of increased magnetism and then letting it move back again, but *always under control of the magnetic pull.*

An ordinary workman, for the purpose of getting more powerful results, might have replaced the magnet of fig. 7 by a more "powerful" magnet, and one of Mr. Bell's letters of 1875 shows that he was working in that direction. But in 1876 he found that he could get the most powerful effects by employing a magnet which was *smaller* than any hitherto known, and of a type which was known to be the *weakest* for the purpose of pulling an armature by means of an electric current. We can now see reasons for this. But that a magnet, which, when combined with an armature in any known form of instrument, pulled it so feebly as to be generally discarded in practice, would, when combined with a diaphragm of the new speaking telephone, give much more powerful effects than any other, was a discovery which required invention and experiment.

Indeed the whole operation of the telephone receiver depends upon the fact that the magnet *always* pulls the armature, and positively controls its motion by pulling it with a strength *exactly proportional to the electrical undulation* operating at that instrument. Mr. Bell, therefore, in his combination produced a new result by using the magnet in a different way, and employing a different property of it; though of course some of its properties are employed wherever this magnet is employed.

The Hughes magnet and its operation are explained by Mr. d'Infréville, *Dowd*, i, 592–8. No expert has controverted his statement.

It does not appear whether Mr. Bell knew of the Hughes magnet or not; but as it was well known in the art, we may assume that he did know of the Hughes machine and the use that was there made of it.

What Mr. Bell did was to take his instrument, fig. 7, and alter the shape of the magnet. When, by altering any part of that instrument, he very notably improved the result, he made an invention. What he made was a new and improved telephone. That it was an improvement is shown by the fact that this alteration in the magnet

has been used in substantially every telephone ever made since, while this peculiar form of magnet is no more used in telegraph or other apparatus than it was before.

His invention may be stated in another way, though it seems to us not so correct a way, by saying that he made a combination which did not exist before; to wit, a peculiar magnet, with a diaphragm armature; and by means of that combination got results different in kind from anything that had ever been got out of a combination in which that magnet had ever been employed, — it had only been employed in printing instruments, — and better and more powerful than had ever been got out of any combination in which that diaphragm had been employed with any other magnet. What he had then made, therefore, was a practical and important improvement in speaking telephones, which could be stated either by saying that he had made *an improved telephone*, or that he had made a *new combination of parts*, which, taken together, formed *an improved telephone*.

Speaking of this simply as a combination, it would not be proper to say that his improved apparatus consisted of a combination of this peculiar magnet and a diaphragm, because such a combination is not operative. It consisted of a combination of this peculiar magnet and a diaphragm, and a framework to hold the two in proper relative positions, with an opening or air space of some kind, in front of the diaphragm-armature for the sound waves to pass in and out. In other words, if you are to state the combination, you must state it as a combination of that peculiar magnet, with all the elements, except the old magnet, which previously existed in speaking telephones; so that to state, even in the form of a combination, just what it was that he produced or accomplished, one can hardly do better than to say that he took out of the existing telephone the magnet which he found there, and put in place of it a different magnet which gave better results. Or, to state it more precisely, what he did (besides permanently magnetizing the magnet) was to wind his coil over *one end* of the leg of the magnet only, instead of winding it over the *whole* of the leg of the magnet. This was the way in which Mr. Bell expressed it in the body of his specification:

"I have also found that the electrical undulations produced upon the main line by the vibrations of the plate *a* are intensified by placing the coil *g* at the end of the bar *f* nearest the plate *a*, not extending it beyond the middle or thereabout."

He had made the invention, and the only question now is as to the correctness of his claim. If the claim be a claim for the Hughes magnet as a new article, it certainly is bad. If it be a claim for that improvement in telephones which consists in winding the coil on the end of the magnet of the speaking telephone, and thereby getting better results, or, to state it differently, that improvement in speaking telephones which consists in combining with all the other parts necessary for the operation of the telephone a magnet with the coil wound on one end of the leg, instead of a coil wound round the whole of the leg, or, to state it still otherwise, that improvement in speaking telephones which consists in replacing one element by a better one, then it is a good claim. Now which is it?

The first rule is, that the claim is, if possible, to be construed to be coextensive with the invention. Mr. Bell's statement of invention in the body of his specification is not that he has made a new magnet, but that he has found that the electrical undulations produced in the speaking telephone by talking to it are intensified when the coil is wound on one end of the magnet; and that is true, and no man knew it before he did it. The claim is to be construed for that improvement in telephones, or that combination of this magnet with the other parts of the telephone, unless the language of the claim is such that it is impossible so to construe it. Two authorities which bear upon this question are of peculiar importance here.

Forbush v. *Cook*, 2 Fish. 668, CURTIS, J. The claim was for a combination of certain parts used in the pattern mechanism of looms for weaving fancy fabrics. The objection made was that the elements specified in the claim, which in form was a combination claim, did not constitnte an operative mechanism, but required in addition other parts not enumerated in the claim, in order to work. Judge Curtis found as a matter of fact that the other parts which were required to make the combination operative were parts which existed in previous looms, and that the invention consisted in putting into the loom the particular elements specified in place of, or in addition to,

other elements which previously existed there. He said that it was not necessary to enumerate in the claim all the parts which were necessary to the operation, but only the particular parts which had not before been used in looms; because, when the patent was for an improvement in looms, the law read into the claim all those parts previously used in looms which were necessary to give effect to the new elements. His language was:

"Nor is it requisite to include in the claim for a combination, as elements thereof, all parts of the machine which are necessary to its action, save as they may be understood as entering into the mode of combining and arranging the elements of the combination. If inclined wires are necessary to the action of the combination specified, so are many other parts of the machine, and all parts necessary to the action and combination specified might be said to enter into the mode of combining and arranging the elements of the combination, and need not be, and ought not to be, included in the combination claim."

Johnson v. *Root*, 2 Clifford, 108; appendix, 637. Johnson, the patentee, claimed to have invented a sewing-machine feed which was infringed by the well-known Wilson feed. The question was as to *when* he made the invention specified by the claim relied on, and that called for a construction of the claim. The facts were, that sewing machines were known before he began; and that the claim was in terms for "feeding the material to be sewn by means of a vibrating piercing instrument . . . substantially as herein described." It appeared that he had constructed a combination of parts in which a vibrating piercing instrument fed along a piece of cloth; but that at the time at which he must prove his invention in order to prevail over Wilson, he had not been able to make a sewing machine with such a feed motion in it which would so effectually coöperate with all the other parts in sewing cloth, that the machine as a whole would practically both feed and sew.

Upon this the Court held that the claim, and therefore the invention, included not only the vibrating piercing instrument, but placing it in the machine. The plaintiff argued "that the feeding instrument was distinct from the devices holding the cloth or material to be sewed"; but the Court instructed the jury that

"there was included in the claim not only the vibrating piercing instrument, substantially as described, but also all the other parts which necessarily act in

connection therewith to feed the material to be sewed in the sewing machine, so far as any function they performed modified the action of the feeding instrument."

Again, p. 640: "The claim must be limited to the means of feeding the material to be sewed in a sewing machine."

The substance of these decisions is, that when the invention to be described and claimed consists in introducing new parts into a preëxisting organized machine, the claim is to be read as if all the remaining parts of the old machine (or their equivalents), which coöperate with the new parts, were enumerated in it; and then the claim is to be constructed either as a claim for an improved machine or a claim for a combination in which all the old parts that coöperate with the new-named part form elements of the combination.

That the Bell patent in question is to be so construed is not even left to inference. The patent shows in the drawing and description a complete speaking telephone. The patentee then says that "the electrical undulations produced upon the line by the vibration of the plate A are intensified by placing the coil *g* at the end of the bar F." Explicitly, he refers to described parts, and he states that the advantage consists in enhancing the effect of an operation, — the production of electrical undulations, — which cannot be produced without the coöperation of the magnet, coil, vibratory diaphragm and the supporting parts.

The language of the claim is as follows:

"5. The formation *in an electric telephone, such as herein shown and described*, of a magnet with the coil upon the end or ends of the magnet *nearest to the plate*."

If he had invented a new magnet, and that were the invention he wished to claim, he might have used the language "the formation of a magnet with the coil at one end": but that was neither his invention nor his claim. His claim is for making that kind of a magnet *in an electric speaking telephone such as he has described*, and then he further enumerates the *plate* as one of the elements specified in his claim. The invention claimed was not made until the specified magnet was so combined with other parts as to make a speaking telephone. That claim would not be infringed by the use of a mag-

net with a coil on one end in a Hughes printing telegraph; the express language of the claim would exclude that. *Rich* v. *Close*, 8 Blatch. 43. It would, therefore, not be anticipated by such an apparatus.

We submit, therefore that claim 5 of patent 186,787 is to be construed as a claim for *an improvement in speaking telephones*, or for *a combination*, because:

First. If so construed it can be sustained; whereas, if construed merely as for a new magnet, it cannot be sustained. That magnet was perfectly well known.

Second. The patent is stated in the opening paragraph to be for an *improvement in electric telephony*.

Third. The description in the body of the specification accords with this.

Fourth. Any different construction would require the Court to strike out from the claim the words "in a speaking telephone" and the words "nearest the plate."

Fifth. Because, by the established rules of law, a claim which states that the invention is for an improvement in a particular class of machines, or even a claim in a patent which purports to be for an improvement in an existing class of machines, is to be read as if the other parts, which in that machine coöperate with the elements more particularly named, are enumerated as a part of the combination; though here the express language of the claim does not leave this even to legal inference.

E. N. DICKERSON,
J. J. STORROW,
For Complainants.

JANUARY 18, 1887.

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Office Supreme Court U. S.
FILED
JAN 21 1887
JAMES H. MCKENNEY
CLERK

BURGOYNE'S "Quick" Print, 146-150 Centre St., N. Y.

Supreme Court of the United States,

THE AMERICAN BELL TELEPHONE COMPANY ET AL.,
Appellants,

AGAINST

THE MOLECULAR TELEPHONE COMPANY ET AL.,
Appellees.

October Term, 668.

BRIEF FOR APPELLEE.

This appeal relates to the 5th claim of the second patent or No. 186,787, of January 30th, 1877.

The Court below held the claim bad because anticipated by the Schellen magnet.

Appellants here claim that though the magnet was old its use in a telephone was new and patentable. That adopting this magnet for a telephone was putting an old device to such a new use as to make it patentable.

We submit otherwise.

The argument of appellant would apply equally to the use of any magnet in a receiver quite as much to one with a long as to one with a short coil.

The quite long examination of Mr. d'Infreville, Dowd 1, 592–8, is not to the point in question.

It was quite unnecessary to prove that the Hughes printing telegraph and the telephone are different instruments, and that the results accomplished by the magnet differ in the two instruments.

The object of the magnet is, however, the same in each instrument. That pnrpose is speed, sensitiveness.

In the Hughes device the quality desired in the magnet is speed.

Mr. G. S. Renwick, Dowd, p. 230, says : If there be any advantage by reason of the greater quickness of action or greater strength of such a magnet as compared with a permanent magnet, * * * such advantage is gained equally by the use of the said compound magnet in the Hughes telegraph and in the Bell telephone."

Mr. Frank L. Pope, Dowd 338, being asked as to the operation of the short coil magnet in the two devices says : "As far as the magnet is concerned, the operation is the same, it being *the object in both cases* to get the *quickest possible action* on the armature."

In the Hughes printing telegraph, of which the magnet described by Schellen forms a part, a variation of the hundredth part of a second in the time of movement of the armature would cause a wrong letter to be printed. The armature in the Schellen magnet is drawn away from the magnet by a spring, whenever the normal magnetism is reduced by the passage through the coils of a current tending to produce contrary polarity in the magnet, and having been thus separated from the magnet is replaced upon its poles by the mechanical action of the machinery which has been previously set in action by its release. In Mr. Bell's patent the movements of the plate or armature both from and to the magnet are produced by the action of the latter when it is used as a receiving instrument."

It thus appears that the feature desired in the Schellen magnet was speed, although the effect or result attained in the Hughes telegraph was the setting in motion and the stopping of a mechanical device. Now, when we turn to complainant's expert, Mr. d'Infreville Dowd Record, volume 1, page 592, Int. 94, he is asked, "Does the apparatus, Fig. 7, require for its armatures *speed* rather than force, or force rather than *speed*, as compared with ordinary telegraphic instruments?" "Ans. *Speed.*"

We thus find that the telephone was a complete instrument with the ordinary telegraph magnet, such as is shown in Fig. 7 in Mr. Bell's first patent, or in the Reis-Legat receiver, or in the Vander Weyde horseshoe receiver. It was found desirable to have a more sensitive and quicker acting magnet. Mr. Bell found such a magnet in the Hughes device, and he adopted it. In the Hughes device the only desirable characteristic of such a magnet is speed; in Bell's device its only desirable characteristic is speed.

In neither case has it any superiority over an ordinary magnet except for speed. Its function in a telephone is precisely that of any other magnet, and is performed in the same way.

After its function is performed the mechanism in each device does different things, but the function of the magnet is identical in each device.

The magnet is conceded to be old. Bell finds it ready to hand and uses it to effect the speed for which it was designed.

Is that invention?

The judgment of the Circuit Court should be affirmed.

GROSVENOR P. LOWREY,
WHEELER H. PECKHAM,
HENRY D. DONNELLY,
Of Counsel for Appellee.

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SUPREME COURT, U. S.
FILED
JAN 24 1887
JAMES H. MCKENNEY,
CLERK

UNITED STATES SUPREME COURT.

No. 667.

THE MOLECULAR TELEPHONE COMPANY et al.

vs.

THE AMERICAN BELL TELEPHONE COMPANY.

ARGUMENT FOR MOLECULAR COMPANY.

GROSVENOR LOWREY,
WHEELER H. PECKHAM,
H. D. DONNELLY,
Of Counsel.

BURGOYNE'S "Quick" Print, COR. WALKER AND CENTRE STS., N. Y.

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Supreme Court of the United States.

OCTOBER TERM, 1886.

THE MOLECULAR TELEPHONE COMPANY, GEORGE BELL, SAMUEL H. BARTLETT, HENRY E. WAITE and JOHN I. WATERBURY, Appellants,

vs.

THE AMERICAN BELL TELEPHONE COMPANY and the METROPOLITAN TELEPHONE AND TELEGRAPH COMPANY.

THE AMERICAN BELL TELEPHONE COMPANY and the METROPOLITAN TELEPHONE AND TELEGRAPH COMPANY, Appellants,

vs.

THE MOLECULAR TELEPHONE COMPANY, GEORGE BELL ,ET AL.

APPEALS FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK.

Brief for the Molecular Telephone Company and other defendants.

[The duplicate references herein to **O.**, signify the Overland Case, to a paged copy of which counsel have had access, as this

brief is going to press. In some cases, the evidence has not been completely transferred to the Overland Record in this Court, and in such cases, our reference to this and other records stand.]

This appeal is from a judgment of the Circuit Court of the United States for the Southern District of New York.

The bill charges an infringement of the rights of the complainants, arising under Letters Patent No. 174,465, issued to Alexander Graham Bell, on the 7th day of March, 1876, and Letters Patent No. 186,787, issued to the said Bell on the 30th day of January, 1877, now by mesne assignment the property of the complainants (pp. 3 to 17, Molecular Record).

The answer denies the validity of the letters; and the alleged infringement of them.

On final hearing upon the pleadings and proofs, a decree was entered for the complainants upon the fifth claim of said Letters Patent No. 174,465; and the sixth, seventh and eighth claims of said Letters Patent No. 186,787 (Record, 2171); and the defendants appealed.

Upon the fifth claim of said Letters Patent No. 186,787 the decree was for the defendants (*Ib.*, 2172) and complainants appealed.

The defenses set up in the answer, and now relied upon by the defendants, are the invalidity of Letters Patent No. 174,465.

Because:

1st. As a patent for a machine, the instrument or machine described and claimed is an inoperative device.

2d. As a patent for a new art, there is in the patent no disclosure of what the art is or any description of the art process that would enable a skilled person to beneficially use it.

3d. Because the claims of the patent include and appropriate mere forces of nature and things which are not subject matter of patent.

4th. Because all the claims of the patent are anticipated or limited by the inventions and discoveries of Reis, Gray, Dolbear, Holcomb, Van der Weyde, McDonough, Varley and others.

As to Letter No. 186,787, the defendants' contention is:

1. That the claims are all anticipated by the inventions and discoveries of the persons named and others.

2. As to both said letters the defendants deny that they infringe any of the claims therein set forth.

Proof of infringement was founded upon the mechanical construction of the defendant's instrument, given by Daniel M. Adee (beginning at p. 77 of Molecular Record); and the evidence of Prof. Charles R. Cross (p. 108, int. 19, and p. 122, *Ibid*), that he had examined and tested the instruments marked Exhibit Defendant's Transmitter and Exhibit Defendant's Receiver, and found that from their construction and method of operation they are adapted, when suitably connected with a battery, to transmit articulate speech; and that when so connected and so operated they use

"the *method* invented by Bell and described in his specification "No. 174,465, for transmitting vocal or other sounds telegraphic- "ally, by causing electrical undulations similar in form to the "vibrations of the air accompanying any sound."

The claims referred to in the decree, Mol. R, p. 2171, are as follows:

5TH CLAIM OF PATENT, 1876, P. 54.

"5. The method of, and apparatus for, transmitting vocal or "other sounds telegraphically, as herein described, by causing "electrical undulations, similar in form to the vibrations of the air "accompanying the said vocal or other sounds, substantially as set "forth."

6TH, 7TH AND 8TH CLAIMS OF PATENT OF 1877, P. 64.

"6. The combination, with an electric telephone such as de- "scribed, of a sounding box, substantially as herein shown and set "forth."

"7. In combination with an electric telephone, as herein de-
" scribed, the employment of a speaking or hearing tube for con-
" veying sounds to or from the telephone, substantially as set forth."

"8. In a system of electric telephony, the combination of a
" permanent magnet with a plate of iron or steel or other material
" capable of inductive action, with coils upon the end or ends of
" said magnet nearest the plate, substantially as set forth."

"ERRORS ASSIGNED."

FIRST. The Court below erred in holding that the 5th claim of Patent 174,465 was valid.

SECOND. The Court below erred in holding that defendants infringed the 5th claim of Patent 174,465.

THIRD. The Court below erred in holding that the 6th, 7th and 8th claims respectively of Patent 186,787 were valid. We assign separate errors as to the holding valid of each of said claims.

FOURTH. The Court below erred in holding that the defendants infringed the 6th, 7th and 8th claims of Patent 186,787. We assign separate errors in respect to the infringement of each of said claims, 6th, 7th and 8th of Patent 186,787.

"Vocal sounds" and "articulate speech" were not convertible terms in the telegraphic art at the date of these patents.

The "vocal sound" of multiple telegraphy was understood to be a mere musical note, sounded at an agreed pitch. Its mechanical alternative would be an organ pipe, or other wind instrument.

Deposition of Dr. William F. Channing, Mol. R., 555:

"As I have already stated in my direct testimony, the expression 'vocal sounds' had been previously used in multiple telegraphy *without any reference to articulate sounds.*"

Deposition of Prof. Chas. A. Young, Mol. R., 394; O., p. 791:

"I understand them to be sounds suitable for *use in multiple telegraphy*, that is, *musical* tones of definite pitch, produced by *the voice* or other means."

Deposition of Prof. Charles R. Cross, Mol. R., 129:

"Cross-Int. 45. At that time was the art of transmitting musical tones, including *vocal musical tones*, by electricity known?

"Ans. The art of transmitting the characteristic pitch of musical sound, including the pitch of a *sound produced by the voice*, was known. The transmission of all the characteristics of any sound, its intensity, its pitch and its quality was not known."

Deposition of Dr. Carl Seiler (p. 15), Clay Commercial Record:

"Q. 18. What is meant by the expression '*vocal sound*,' and what is its organ?

"Ans. *Vocal sound* is the utterance of a sound of voice, and is common to all animals who possess the organ of voice.

"Q. 19. What is meant by articulate speech, and what is its organ?

"Ans. Articulate speech is the *series of sounds* and notes uttered in arbitrary sequence to express ideas. These sounds and noises are divided into two classes, called vowels and consonants.

"Q. 20. Does *vocal sound include articulate speech* according to the sense in which these respective terms are used by writers on this subject—and furnish illustration, if you are able to do so?

"A. Vocal sound or voice is *a different manifestation* from *articulate speech*, for, as already indicated, the one may exist without the other.

"Carpenter, in his Principles of Human Physiology, 1876, page 844, says: 'It is necessary to bear in mind that vocal sound and speech or articulate language are two things entirely different, and that the former may be produced in great perfection where there is no capability for the latter.'

"Flint, in his text-book on Human Physiology, 1877, page 549 and following pages, treats the subject under the two heads of 'voice' and 'speech.'

"Marshall, in his Outlines of Physiology, London, 1867, Vol. 1, page 248 and following pages, treats the subject in the same way. Lemuel Brown and Emile Behake, 'Voice, Song, and Speech,' 1884, page 35, say: 'Voice is sound originated in the larynx, and may

be produced by any animal possessing that organ. Speaking is voice modified by the cavity of the mouth.' This is the general mode of treatment by authors on the subject."

Deposition of Prof. A. G. Bell, Mol. R., 1600-1603:

Int. 51. * * *

"A. By reference to a letter that I received from him, dated Oct. 21, 1874, in which he referred to some letter that he had received from Mr. Elisha Gray concerning experiments in telegraphing 'vocal' sounds.

"Int. 59. The letter refers to an interference with Mr. Gray. Were you then in interference with him at the Patent Office; and, if so, upon what subject?

"A. I was then in interference with Mr. Elisha Gray upon the subject of *harmonic multiple telegraphy*."

(This shows that Bell and Gray both used the words "vocal sounds" in the same sense, that is, as applied to multiple telegraphy.)

Mol. R., 1715:

"x-Q. 435. The old Reis telephone already referred to in x-Q. 383 and the answer thereto was a telephone, which was *operated by the human voice*, and by *vocal sounds*, and by sounds produced by musical instruments, was it not?

"A. I presume so."

The *art* of reproducing in any manner, vocal or other sounds, and articulate speech, *is one art.* It is the art of reproducing the vibrations which must always accompany any original sound or sounds, whether they be simple or complex.

When the reproduction of either class of sounds employs the electric current, the natural *modus operandi* is, changes in the strength of the current occur which in degree and rapidity of succession correspond substantially to the air vibrations of the specific sound or sounds being transmitted.

These changes are now commonly called undulations.*

* This term is not adopted because the current is supposed to undulate as the waves of water undulate, but because a line drawn

There are only two ways or "methods," so far as is yet known, for producing the changes of current needed in the practice of the art of reproducing, or—as it is erroneously called—transmitting, sounds telegraphically—viz.:

(1) By varying the initial, or electro-motive force of a current.
(2) By varying the resistance to the flow of a current, without varying its initial, or electro-motive force.*

These two ways of producing the needed CHANGES constitute two *distinct and different methods* of practicing the art of "transmitting vocal or other sounds" (and also articulate speech) "telegraphically * * * by causing electrical undulations similar in form to the

---

on paper to represent graphically the increase and diminution, or rise and fall of current strength would show a surface line something like the surface of water, when in motion under the influence of the wind.

* According to Ohm's law, if C be the current-strength, E the electro-motive force, and R the resistance in any electrical circuit, we have $C = \frac{E}{R}$, and, hence, we see that the current-strength in any circuit can be *varied in two distinct ways*, either, first, by varying the resistance and keeping the electro-motive force constant; or, secondly, by varying the electro-motive force and keeping the resistance constant. These two ways of varying the current-strength give rise to two distinct classes of telephone, of which we shall now give examples. * * *

337. REIS' TELEPHONE.—This is an example of a telephone which is worked by varying the resistance in the circuit, the electro-motive force being constant.

* * * * * * *

338. BELL TELEPHONE.—The Bell Telephone, so called from its inventor, Professor Graham Bell, is an example of a telephone which is worked by varying the electro-motive force and keeping the resistance constant.

Ferguson's Electricity, W. & R. Chambers, London and Edinburgh, 1882, pp. 391, 393.

vibrations of the air accompanying the * * * sounds * * *."

THE FIRST METHOD* is that figured in Mr. Bell's patent by a drawing exhibited below; and to which drawing, counsel for complainants have been heretofore understood to say the 5th claim above quoted, solely relates.†

By this method the efficient current—that is, the particular current which affects the receiver—is generated *in* the transmitter by magnetic action; and is efficient by reason of variations in its *initial* force, called electromotive force.

This is called the *magneto method.*

When, instead of a permanent magnet, a battery is employed to magnetise the magnet it is called, a *magneto-electric method.*

THE SECOND METHOD is that employed by the defendants, and by the complainants.

---

* "I feared that the induced current would be insufficient. * * *"
"I began to look about for some other *method.* * * *"
Testimony of Mr. Bell, Mol. R., pp. 1650, 1651.

"First part of the question * * * referred to my *method* of inducing currents * * * (p. 1651).

"During the winter of 1874 * * * this feeling led me to seek *some method* by which the voice instead of *producing* the electrical current used, should merely *modify* a current produced by other means. In May, 1875, I devised *a method* of varying the resistance of a galvanic circuit by the action of the voice. * * * I was still carrying on experiments and researches regarding *this method.* * * *" (p. 1660).

† Perhaps the language of counsel in argument has been misunderstood. The present position of complainants on this point is probably expressed in the testimony of their expert, Prof. Cross, in the Am. Bell Tel. Co. vs. New Jersey Tel. Co., Cir. Court, Dist. of N. J. (stipulated into the Molecular case), Cross-Interrogatories, 52 to 71, printed in the Circuit Record in that case, which will be handed up.

By this method a current of constant electro-motive force is generated in a chemical battery, and is made effective for work in telephony by the introduction of a varying degree of resistance to its flow through the circuit; which variation of resistance may meet it anywhere between the battery and the receiver.

This is the *variable resistance method.*

The general plan of this argument is, to bring under consideration,

FIRST. The difference between

(1) The instrument (and its method) patented by Mr. Bell; and
(2) The instrument (and its method) used by the defendants; with a reference to models of the various apparatus.

SECOND. Some facts known or generally assumed to be true in acoustics, electricity and magnetism; with a chronological notice of the developments of these sciences, in respects material to the questions at issue in the case.

THIRD. An historical statement of the development of the art of telephony as at present practiced; showing its beginning, respectively with Charles Bourseul, of France, in 1854, and Philipp Reis, of Germany, in 1860; and its course thence through various experimenters to Bell in 1875; ending with Edison, Hughes and Blake in 1877, 1878, and succeeding years.

FOURTH. A consideration of the patents of Mr. Bell; and the bearing thereon of the facts already shown.

FIFTH. Questions of law pertinent to the facts.

In this manner counsel for these defendants hope to aid the Court in determining the question—

What has Alexander Graham Bell done to entitle him

and his assignees to the unexampled reward of a complete monopoly of this art?

FIRST.

Statement of some of the elements of the commercial telephone now in use, which distinguish it from the Bell apparatus figured in Letters Patent No. 174,465, of 1876.

The commercial telephone in use under the name of the "Bell telephone," is now familiar to all.

In a popular sense any question relating to the invention of Mr. Bell would be understood as referring to a certain known form of instrument enclosed in a wooden box of uniform design; which usually hangs upon the walls of a room; into which persons, desiring to communicate at a distance, speak in a well-known manner; and at another part of which they may listen. This form is so fixed upon the imagination, as the true, concrete representation of what many suppose to have been Mr. Bell's intellectual conception, that it is thought desirable—even in introducing this case to a court, familiar with cognate subjects—first, to point out what things in this box are plainly and confessedly *not* the invention of Mr. Bell.

This process will result in eliminating from the cases before the Court *every element* which in mechanical commercial telephony is employed in *transmitting speech. No part of that instrument was invented by Mr. Bell.* And, in justice, it should be stated that no part of it is now claimed by the complainant to have been invented by him.

This elimination results in bringing into view what

Mr. Bell *did* invent, to wit, the unfamiliar little device of which a drawing is given below (p. 19); being a copy of the drawing numbered Figure 7, attached to Bell's patent of 1876. This is the telephone (now so called, though not called or recognized as such at the date of the patent), and the only one ever invented or claimed by Mr. Bell—at least the only one which these records bring into issue.

Lest, however, even for a moment, counsel should seem to be begging or ignoring the question in controversy on this appeal, it should at once be said that it is claimed for Mr. Bell that a certain *principle or method of operation*, under which that little apparatus talks—when it talks—was secured to Mr. Bell by the 5th claim above quoted; that that method of operation is employed whenever and however speech is transmitted; and that such employment is unlawful unless with the consent of the complainant.

SECOND.

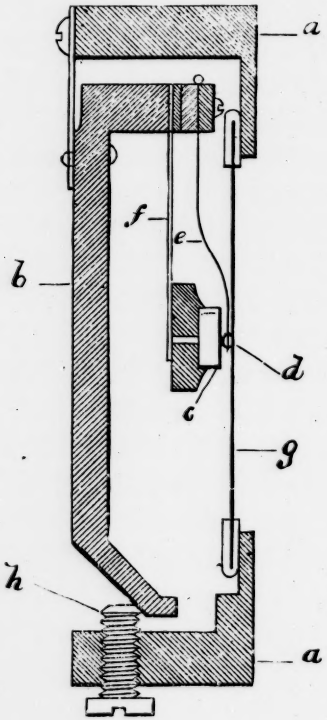
The methods of Bell's Fig. 7, and of the defendant's and all other commercial transmitters,—contrasted.

1ST. THE VARIABLE RESISTANCE METHOD AND TRANSMITTERS LIKE THAT OF THE DEFENDANTS.

The variable resistance method requires, like the magneto-electric method, but one circuit; although two circuits called primary and secondary, are used in commercial business, where places more than say one-half mile from each other are to be connected. The explanation now to be given will, for greater simplicity, describe the transmitter as an element in one single cir-

cuit consisting of battery, transmitter, receiver and the necessary connecting wires.

The Blake transmitter, being the one chiefly used by the defendants, and therefore more commonly known than any other, will be adopted as the example by which to illustrate the mechanism and method of operation of the class of transmitters to which it belongs, and which are popularly called microphones.



The function performed by this transmitter is to interpose a resistance to the flow of current from the battery through the circuit above described, which may be made to vary. This it does by means of a

piece of carbon (*c*) and a piece of platinum (*d*) which are held in normal contact by two springs (*f* and *e*), and from one to the other of which, through the platinum and carbon contact, the current must pass. The pressure of the springs is subject to be disturbed by many causes,—even by the jar of a sound made in the neighborhood; and the resistance between the contact points *c*, *d*, is varied as this pressure is varied.

The Blake transmitter consists essentially (1) of a flat piece of thin board (*aa*) with a small round hole in the middle; (2) a ring of cast iron screwed to one side of the board, carrying a cross bar or spring lever (*b*), to which near its upper end is fastened a square block of non-conducting material; (3) a thin light spring (*e*) one end of which is inserted into the block of non-conducting material; and the other end of which hangs down opposite to the hole in the centre of the board, and carries on each of its faces a small point of platinum (*d*); (4) another but stiffer spring (*f*), the upper end of which is in like manner inserted into the block of non-conducting material, carrying upon its lower end—which hangs parallel to the first mentioned spring,—a piece of carbon (*c*) on the face next to the other spring; (5) a piece of thin metal called a diaphragm (*g*) which is fastened at its edges to the iron ring—though insulated from it—so as to close the small hole in the board on the side next the springs. The cross bar or spring lever is subject to adjustment by a screw (*h*) which bears against its lower end so that that end may be pressed in towards the stiff spring which is parallel to, and next it. The tension of the two springs above described is such that they press lightly against each other,—bring the piece of carbon (*c*) on the stiff spring into contact with the platinum point (*d*) on one face of the lighter spring,—and also press the platinum point on its other face against the diaphragm. A battery is connected by a wire, to the upper part of the stiff spring; another wire is connected to the upper part of the light spring, and is

led thence to the required distance where it is connected with a telephone receiver (assuming that no secondary circuit is used) and is carried thence to the ground or back to the battery, thus making a complete circuit over which an electric current may flow. The course of the current is, (1) from the battery to the stiff spring (*r*); (2) down that spring to its lower end; (3) through the carbon (*c*) block of that spring, to the platinum point (*d*) of the other spring; (4) through that platinum point to the light spring (*e*), and (5) up that spring to the place where the other wire is attached; (6) thence through that wire—called the line, or line wire, to the receiver; (7) and through the receiver to the earth or by another wire back to the battery. The contact of the platinum points with the diaphragm on one side and the carbon point on the other is such that even the slightest jar will cause the platinum and carbon to be pressed more closely together, or driven measurably apart. A strong jar (such as results from too loud speech in front of the diaphragm for instance) may when they are properly adjusted for transmission of sound cause them to be for a very brief period, say for the $\frac{1}{100}$ part of a second, and for a brief space, say for the $\frac{1}{1000}$ to $\frac{1}{30000}$ of an inch, to be separated. Such a separation being regarded prejudicial to the transmission of speech, is sought to be guarded against by an adjustment of the screw and cross-bar; and also by an avoidance of too loud speaking.

The apparatus being set up, a current is permitted to flow from the battery through the circuit. This it does by reason of what may be considered as a force behind it, resulting from the interaction of the elements of the battery. This is called electro-motive force. It is not a force of the current, but of its generating source—something which compels the production at places distant from the battery, but connected with it by a conductor—of phenomena, which are attributed to a force originating in the battery. In ignorance of what

does actually occur, the supposed transference has been likened to the flow of water, and, for want of any better term, the electrification of the conductor has been called a current. The only thing known is, that when the elements of the battery are permitted to act, certain phenomena occur throughout the entire circuit—however long it may be—at almost the same instant; so that, if the battery be in New York, the phenomena of electrification can be made to appear in San Francisco in about three-tenths of a second.

This flow meets a resistance in the circuit which can be definitely measured and stated; and which can be increased or decreased in various ways. One way is to increase or decrease the cross section of the conductor at some point, thus narrowing the path for the current; as if a flexible tube, through which water is flowing, should be compressed by the hand. If now we suppose the diaphragm of a telephone transmitter to be vibrated by speaking before it, it will press inwards, thus driving the light spring back and pressing the platinum more against the carbon. This pressure brings many molecules—perhaps many millions—into actual contact, which were not in contact before. This increase of contact enlarges the cross section of the conductor at that point; widens the path of the current, and the resistance to its flow is proportionally *diminished.* When the diaphragm reacts it relieves this pressure; there is a diminution of contact; the cross section is diminished; the path is again narrowed and the resistance *increased.* If this variable contact is made correspondingly to the rarefaction and condensation of air constituting sound waves, the current is said to be "moulded" into the form of the sound waves;* and, by help of other arrangements in the receiver, speech is reproduced.

* Mr. Dickerson, in his very able argument in this case at the circuit, said:

"* * * * *a new art*, founded upon a new discovery; and that

This way of reproducing sounds is called the variable resistance method, and a transmitter thus operating is called a variable resistance, or variable contact, transmitter.

Such a transmitter* is *incapable of acting by the magneto method;* as a magneto transmitter is incapable of acting by this method.

The changes in current strength being called undulations, the current in which they occur is called an undulatory current.

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it includes and covers all telephones in which the electric current is *moulded* into the form of speech," &c. (p. 2).

" But the essence of his invention is to 'undulate' or mould a current into the desired form by means of the air vibrations." * * * (p. 7).

* The prototype of all such transmitters is the Reis transmitter. The *moulding* process manifestly takes place at the contact point of the transmitter. That the Reis transmitter is capable to " mould " or undulate an electric current by means of, and in substantial accordance with, aerial vibrations accompanying any sound is abundantly proven; but for the present the fact may be taken from the lips of Prof. Cross, plaintiff's expert, in the case of The Am. Bell Tel. Co. vs. The New Jersey Telephone Co., which will be hereafter referred to as the N. J. McDonough case. The testimonv of Prof. Cross is introduced into this case by stipulation :

" x-Int. 74. Is there no practical method of determining whether in any particular apparatus the deformation and loss of portions of the electrical undulations have reached such a point as to place the apparatus outside the scope of Bell's fifth claim, or in other words, so that the apparatus will cease to operate upon the method referred to in that claim ?

" Ans. If an actual piece of apparatus, which could be experimented with, were produced, it would be possible to determine whether it did or did not operate according to the method described in the fifth claim.

" x-Int. 75. What would be the practical test?

" Ans. One would observe the construction of the apparatus, the mode in which it was intended to operate if this were stated, and the results actually obtained as apparent to the ear.

" x-Int. 76. Could you determine the question by the last test alone ?

" Ans. I have not found any difficulty in determining it in any apparatus that I have ever seen.

The essential characteristics which distinguish this method are, that the CONSTANT *is a voltaic current originating in a battery, disturbed by variation of resistance—thus creating an undulatory current of electricity—and that the source of efficiency is the battery.*

A secondary circuit is now universally used in commercial telephony, not because it is necessary—

"x-Int. 130. Do you know of any method of adjusting a Blake transmitter so that it will operate efficiently otherwise than by listening to a receiver joined in the same circuit?

"Ans. Not of any method which would be a practical one and satisfactory. I know of no other which has been used.

"x-Int. 131. Can you tell by merely looking at the Blake transmitter whether it is so adjusted as, when spoken to, to produce electrical undulations in the circuit similar in form to the air waves acting on the transmitter?

"Ans. I do not think that I could tell certainly by simply looking at it when it was not being operated, which I assume to be the condition supposed by your question. I think that I could adjust it, if I could see the electrodes, so that it would produce such undulations; though I do not suppose that I could so adjust it as to give the best results in transmission. I have never tried to adjust the instrument in this manner, however, and so may be mistaken in my impression.

"x-Int. 132. If you were endeavoring to transmit speech with a Blake transmitter so adjusted that it would not transmit speech, would the apparatus embody the invention of the fifth claim of Bell's patent of 1876?

"Ans. I should think that would depend upon how it was adjusted. If it failed to transmit speech because it did not transmit any electrical undulations, or because those which it did produce were not similar in form to the sound waves producing them, I should not think it would embody the method and apparatus of that claim."

"x-Int. 135. You know it to be a fact, do you not, that the electrodes of a Reis transmitter can be so adjusted relatively to each other, by the mode in which the instrument is talked to that it will transmit speech?

"Ans. I have been able to transmit speech intelligibly by speaking gently to a Reis transmitter in circuit with a battery and Bell magneto-receiver.

"x-Int. 136. At such times, as you understand it, the Reis

or even desirable for the correct transmission of speech—simply. It is when speech is to be transmitted over a considerable distance, that it is necessary, to reinforce the power of the current to overcome the resistance of a long line. This object—essential to telephony as a *commercial business*, but non-essential to it as a patentable art—is accomplished by an induction coil and the establishment through it of a secondary

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instrument is producing electrical undulations similar in form to the air waves?

"Ans. It is.

"x-Int. 137. And embodies the invention of Bell's fifth claim of the patent of 1876?

"Ans. I understand that it does when so operated.

"x-Int. 139. Did you find that you were also able, with that same Reis transmitter to so adjust the electrodes in their relation to each other simply by your mode of talking to it that it would not transmit speech?

"Ans. When I talked to it loudly, so that the circuit was broken frequently, I was unable to transmit speech by it.

"x-Int. 140. Did it at such times embody the invention of Bell's fifth claim?

"Ans. I should say that it did not.

"x-Int. 141. Then according to your belief, the determination of the question whether or not a Reis transmitter embodies the invention of the fifth claim of Bell's patent of 1876 does not depend upon the *construction* of the instrument or the relation of the parts to each other when at rest, but upon the *mode in which the instrument is used.* Is that correct?

"Ans. It is."

Thus we have the controversy as to anticipation charmingly simplified. Any Blake transmitter which will NOT *talk is a Reis transmitter; and any Reis transmitter which* WILL *talk is a Blake transmitter!* This distinction *does not arise from the inventor's purposes,*—deducible from the construction of his instrument or otherwise—but from the changing purpose, or caprices, or differing skill and intelligence of operators. The chief test is, listening! If one of Reis's old machines should be heard, its author is Prof. Blake. If one of Prof. Blake's new instruments fails to speak, its disgrace is imputable to its inventor, Mr. Reis! *From which it results that a Reis transmitter runs great risk of never being a Blake transmitter in the hands of complainant's experts.*

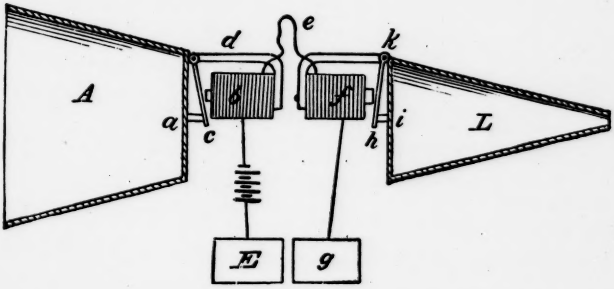
circuit, in which currents not having their rise in the battery are set in motion. These currents possess a greatly increased power of penetration, so to speak, from which fact the induction coil is sometimes called an *electrical lever*. Its first use as an adjunct to a sound-transmitting apparatus was by Dr. Wright in connection with a Reis telephone previous to 1867.

Ferguson's Electricity (1867), p. 258.
Molecular Record, p. 781.

2d. Bell's Magneto-telephone and its Methods.

We may now consider the apparatus actually shown in the patent of 1876, and *its* method of operation.

The instrument figured and in part described by Mr. Bell in his patent of 1876, No. 174,465, is shown in the following drawing :



It will be seen that a battery is represented, which is the source of voltaic electricity flowing freely from the battery through a wire which leads to the transmitting apparatus, which it enters by winding about a short piece of soft iron *b*—the convoluted parts being insulated from each other and from the iron core by a silk covering. The wire having been sufficiently wound around the soft iron core is led away *e* to the distant receiver, where it is wound about a similar soft iron core *f*, and

thence to the earth—thus completing the circuit with the battery. This core and single coil constitute when a current is flowing, an electro-magnet—which is not, however, to be confounded with *an induction coil.* There is but one circuit; and that extends from battery to receiver—however great the distance. In its course the current meets normally, no changeable resistance.

The figure shows a cone, A, one end of which is covered by a membrane *a*, to the centre of which, on the side next the coil, is attached a metal armature *c* which is an inductive body—when itself magnetic, or when the core of the adjacent coil is magnetic. At the other and receiving end of the line is seen a similar arrangement of armature, membrane and cone *h*, *i*, L, except that the end of the receiving cone is made smaller for convenience in hearing. If, now, the battery current begins to flow, it passes through the wire wound around the soft iron core *b*, and over the line *e*, on, to the second series of convolutions around the second soft iron core *f* and thence to the earth. In obedience to well-known laws of electro-magnetism, in passing around them, it causes each of the soft iron cores to become magnetic, and so remain, so long as the current is flowing. If now a sound or concussion happens in front of the membrane *a* in the transmitter, it will produce upon the membrane and its armature *c* an inward motion toward the magnet *b*, to be followed by an outward motion away from it. These motions of the inductive armature, by a well-known law of what is called magnetic induction, produce *new* and artificial currents in the coil of the electro-magnet, which add themselves to the current there flowing—causing it to be of a lesser or greater strength according to the movement of the armature to and from the magnet, and to the violence of such movement. Thus, if the normally constant strength of the current from the battery be taken at a unit of 100, one movement of the armature will set up an extra current, which being added, or

as the technical phrase is, superposed, upon the constant battery current, will cause it to be 99; and again, upon the opposite movement of the armature will increase it through various degrees to 101.*

The increase and reduction, according to these well-known laws, will be in exact proportion to the violence and extent of the armature movement. These changes in the intensity of the battery current are also called undulations; and doubtless for the same reason, viz.: that the customary graphical representation of them will show a wavy line—as will also, any graphic chart of rise and fall in the price of wheat. The constant battery current as will be perceived is not the efficient cause of work, and has theoretically no part in that work. Its sole function is to keep the soft iron core, magnetic. *This is proved by withdrawing the battery altogether and substituting permanent steel magnets in place of the soft iron electro-magnets, when no difference will be found;* from which it is apparent

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* These proportions of increase and decrease from a normal current strength of 100 are illustrative only, but in fact they are grossly beyond any ratio of variation, which actually occurs. The strength of the magneto telephone current is estimated to be about one thousand million times less than the battery telegraph currents in use. Ganot's Physics, § 930, p. 871. The amplitude of the exceedingly minute air vibrations which cause the currents will account for their great weakness. Lord Rayleigh has made experiments from which it appears that the note of a whistle is audible at a distance at which the amplitude of the vibrating particles of air is less than a millionth of a millemetre. Deschanel's Natural Philosophy, Part III., D. Appleton & Co., 1883, p. 838. Whatever battery power is in use therefore in any actual telephone circuit, the induced current which can be generated by a magnet deriving its magnetism from that battery will be in such proportion to—and its effect upon the battery current will be in such degree—that we might, in a rough way, and without risk of being far wrong, represent the battery current graphically by a line equal to the height of a four-story house, upon which, to represent the magnetic impulses, should be superposed another line, of the thickness of a single hair.

that whereas in the variable resistance method the *battery* is *essential* and the induction coil (used only where a secondary circuit is desired) non-essential; in the magneto method the *battery* is *non*-essential and a coil is essential,—for transmission.

Bell's Invention—What it was.

For the purpose of more clearly exhibiting what Professor Bell has set forth and claimed in Fig. 7, we may regard the apparatus shown as consisting of two small dynamo-machines joined in circuit, both of which may be operated by the mechanical energy of sound vibrations acting on the extended membranes to which their armatures are respectively attached. Either of these machines may be operated by the mechanical energy of sound, thereby setting up a current which—the circuit being, as we may say, hermetically closed—must traverse the other machine. As the motions of the membrane will vary with the number and loudness of the sound waves in a given time, the current will vary accordingly, and so the magnetism of the other machine varying will cause its armature and attached membrane to vibrate, and thus to imitate the motion of the first, and so to emit a similar sound.

The *novelty* in all this consisted in the use of the *energy of air waves*, to mechanically ACTUATE A DYNAMO machine, and to cause it—*not* to MOULD, as is sometimes claimed—but to CREATE the electrical currents which are to do the work.

The essential characteristic which distinguishes **this** *method is: A magnetic field disturbed by the shifting presence of an inducing body; which thereby creates electrical undulations in the wire. The efficient, is the magnetic force; its source is the magnetic field; and the battery current is not in any sense the cause of work.*

In the **variable resistance method,** the operative current has its source in a battery, and flows thence with a constant energy and direction; and the needed changes in it are caused by a variation of the resistance to its flow.

This is known in the arts as the "loose contact," "variable contact" or "variable resistance" method. In every apparatus ever devised to work by this method —beginning with that of Reis in 1861—the necessity to keep the contact loose introduces a possibility that it will be *broken*, by *too great loudness* in the tones which are sought to be transmitted. In fact, the Blake transmitter frequently breaks contact in this way, and for this cause. The circuit of which a loose contact of electrodes is a part, can never be spoken of as a "closed circuit" (within the sense of this patent, which shows *only* closed circuits, incapable of ever being open), any more than any Morse circuit, which like the former *may sometimes be open and sometimes closed.*

In the **magneto method** the battery current is not effective for reproducing speech, its sole function being, as above stated, to render the soft iron core magnetic. If for that a steel core, permanently magnetic, be substituted, the battery may be abandoned altogether.

"Cross-Int. Do you then think that in the operation of Fig. 7 of Letters Patent No. 174,465 the voltaic current has any other function than to magnetize the electro-magnet?

"Ans. It seems to me that this is the only function which the voltaic current has in Fig. 7."

Deposition of Prof. Chas. R. Cross, Mol. R., pp 126-7.

The source of the effective current is in the movement of the metallic diaphragm or armature in front of the magnet—whether it be an electro-magnet or permanent magnet.

In this—the magneto method—the circuit was prop-

erly designated by Mr. Bell in his patent as a "closed circuit"—because there is *no possibility of opening it.*

And at this point we urge upon the attention of the Court that the terms "continuous current" and "closed circuit," when used in the patent, or in any with reference to Mr. Bell's claims are to be construed in harmony with, and in subordination to, his drawings and delineations, *i. e.*, as being, by reasons of the mechanical structure and connections shown, incapable of being other than "closed," or "continuous." As Mr. Bell was dealing with a general principle of operation which he illustrated, we most strenuously insist that no circuit which is capable of being either open or closed according as accident or design may determine, is the "closed circuit" of the patent; and similarly, that no current flowing in a circuit where it may be continuous or discontinuous, as accident or design may determine, is *the* "continuous current" of the patent.

These two ways of producing current changes by the energy of sound waves are TWO DIFFERENT METHODS in the arts and in the law.

The defense consists in part, in the contention that these two methods of effecting electrical action in the transmission of speech are in law, as in art, different; and that a *patent for the last is not infringed by the practice of the first*, method.

The judgment of the Circuit Court sustains the allegations of infringement under the fifth claim, and no other claims of the patent of 1876; and the opinion of the Court shows that it is the so-called "method" portion of the fifth claim, which is deemed to have been infringed.

The apparatus portion could not be considered infringed, since the two (transmitter) machines are essentially different, *neither being capable of use in*

the place of the other. The one is adapted to vary the forces of a current flowing *through* it by interposing opposition to its flow. The other is adapted to the introduction in the current flowing—*not through it*, but in its neighborhood—of new magnetic impulses which have the effect to reinforce the strength of that current; and by withdrawal of that reinforcement, to weaken it.

As to the parts of Bell's device, the limits of novelty will be seen when we know that Reis used the mouthpiece membrane (Reis–Bourseul Pub., p. 33); Pickering (Overland Rec., p. 208) and Bourseul, the metallic diaphragm; Shellen, the permanent magnet with the coil on the end encircling an electro-magnet exactly as figured in the Bell Patent of 1877 (Mol. Rec., p. 748); Reis–Legat, the electro-magnet (Reis–Bourseul Pub., p. 29); and Wright, the induction coil (Ferguson, Electricity, p. 258).

At this place we will briefly,—and in advance of fuller discussion hereafter,—refer to the patented methods.

The first is a method for producing electrical undulations in a closed magneto circuit, as follows:

Claim 3: "The method of producing undulations in a continuous voltaic *current* by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting-wire itself, in the neighborhood of such bodies, as set forth."

The second is a method for producing electrical undulations in variable resistance circuits, as follows:

Claim 4: "The method of producing undulation in a continuous voltaic *circuit* by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing or diminishing the power of the battery, as set forth."

The third is for *transmitting* sounds telegraphically, &c., as follows:

Claim 5: "The method of, and apparatus for, transmitting

vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

The third and fifth claims are illustrated by an apparatus, Fig. 7, which—long after the date of the patent—is said to have proved operative, though it has never been in use.

This is, as already shown, an apparatus for *transmitting* sounds by the method of causing undulations in the magneto method, *i.e.*, by manufacturing currents, so to speak, in the transmitter, using for power the identical sound waves which it is desired to reproduce. The idea of utilizing the power of the sound waves to cause a reproduction of themselves was old, *but the idea of using them in multiple telegraphy, to actually create the needed current, was new and ingenious.*

For this Mr. Bell will always have due credit from the present counsel of the defendant.

No apparatus for *transmitting*, etc., by causing undulations in the *variable resistance method* is shown, or even hinted at in the patent.

A way of creating undulations in a voltaic current through a circuit capable of being open or closed, is stated.

But how—that is, by what method or apparatus—these undulations can be put into a form similar to any sound, or can be used in vocal or other sound transmission, we are not told.

"It was known long before the date of Mr. Bell's patent that the resistance of a circuit is varied without being broken by variations in the intimacy of contact or amount of pressure between two electrodes in contact, from one to the other of which a current is passing." (Prof. Cross, Ans. 62, p. 110, Mol. R.)

The language of the specification on this subject referred to by Prof. Cross (Mol. R., p. 107) to sustain

their broad interpretation of the 5th claim is as follows :

"Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit. * * * For instance, let mercury or some other liquid form part of a voltaic circuit; then the more deeply the conducting wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current. Hence the vibration of the conducting wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed produce an undulatory action in the current by alternately increasing and diminishing the power of the battery."

Manifestly Bell had not then discerned that the sound waves could be utilized to vibrate a portion of the circuit so as to vary its conductivity, thereby producing corresponding electrical variations therein, and sonorous vibrations at the receiving instrument. He did not suggest any apparatus for such a process in his patent; and there is no evidence that he knew anything or had thought anything upon the subject.

Further invention was required for this.

Such invention had been previously made by Elisha Gray, and a caveat therefor filed in the Patent Office previous to the granting of Mr. Bell's patent (Mol. Rec., p. 895). On the 10th of March, three days after the granting of the patent, and immediately after his return from Washington (where he certainly obtained *some* knowledge of Gray's invention—*how much* we do not mean to discuss at this place) Mr. Bell made a *variable resistance* transmitter with which, for the first time, he obtained articulate sounds (Mol. R., p. 2083).* If

* The incongruity of the words last quoted—from the patent, has always excited surprise and curiosity among students of Bell's patent. The astounding results of a comparison of different copies of the specifications in the record, and which, unless satisfactorily explained, seem to demonstrate that these words were

the device was his invention, it was either made before the granting of the patent, and was therefore abandoned, by not being described; or was made after, and therefore cannot sustain a previous broad claim for a process. In either case, so much of his alleged invention as consists (by complainant's present construction of the patent) in the transmission of sounds by undulations, resulting from variation in resistance, was not sustained by any "pointing out," etc. (R. S., 4888), of any device old or new with which that operation could be carried on.*

That Bell had not pointed out a liquid transmitter in his first patent is proven by the fact that in his second patent he says "I have heretofore described and exhibited such other means of transmitting sound, as will be seen by reference to the proceedings of the American Academy of Arts and Sciences, Vol. XIII." That was in a communication made to the A. A. & S., May 10,

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fraudulently added after the application was filed and sworn to, will be left to be dealt with by counsel for Drawbaugh, in whose record the material evidence appears.

* Deposition of Prof. Gray, Dowd Case.

Int. 49. Will you state how the knowledge which you got late in 1875 of the so-called lovers' telegraph aided in the production of the invention of a speaking telephone such as is described and represented in your caveat, filed February 14, 1876?

Ans. The fact that all the vibrations, however complex or different in form, that are produced in uttering any given word or sound were transmitted longitudinally through a fine thread suspended from the centre of a diaphragm capable of responding to all the aerial vibrations made by the uttering of a word or sound, and connected to a similar diaphragm at the other end of the thread, which might be from one to two hundred feet in length, proved to my mind that all the conditions necessary for the transmission of an articulate word were contained in any single vibrating point capable of responding, as before stated. I saw that if I could reproduce electrically the same motions that were made mechanically at the centre of the diaphragm by speaking upon it, such electrical vibra-

1876. He does not rely on anything in the first patent as pointing out any " means " or apparatus—as is required by the law to sustain a method claim.

Western Electric Manufacturing Co. vs. The Ansonia Brass and Copper Co., 114 U. S., 447 (452).
O'Reilly vs. Morse, 15 How., 62 (118, 119).

The method of " transmitting," etc., was given to the world in express association with one, and only one, apparatus. That apparatus is Fig. 7. Figure 7 is incapable of application as an alternate or substitute for the liquid, or any other variable resistance transmitter. Fig. 7, or its equivalents cannot, therefore, be relied upon to satisfy the requirement of the law, that a patent for a process must contain a description of some apparatus by which the process can be applied with beneficial result.

Tilghman vs. Proctor, 102 U. S., 729.

The contention of the complainants begins with a confounding of patented methods, and results in monopolizing a law of nature; on the ground that by either of two processes,—one of which the inventor in-

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tions would be reproduced upon a common receiver in the same manner that musical tones were; and from the fact that the electrical vibrations were the same in respect to rate, amplitude and form or complexity as the motions made in the air by uttering words or sounds, it followed that the receiving diaphragm would be thrown into mechanical vibration or motion of a corresponding character, and consequently reproduce the same word or sound. The fact that the longitudinal movement (in water or other fluid of poor conducting quality) of a wire or some good conductor of electricity, with reference to another wire or metal conductor, produced variations in the resistance of an electric circuit proportional to the amplitude of movement was old in the art at that time; so that the last link of knowledge necessary to solve the problem in my mind was furnished in the capabilities of the longitudinal vibrations of the string of the before-mentioned so-called lovers' telegraph.

vented and pointed out an apparatus for, and the other of which he neither invented nor pointed out any apparatus for—this law of nature can be set in motion.

The "method" of "transmitting," truly intended by the Patent Office, in the 5th claim, must be *a method*—or *the* method—*by which that apparatus can work;* and the apparatus intended, must be *Fig. 7, or some equivalent* by which that *method can* be worked.

THIRD.

The Scientific Basis of Telephony as an Art.—History of the Art.

It is necessary in order to appreciate truly the bearing of the complainant's patented claim upon the actual operations carried on by the defendants, to have in mind some general facts, *theories,* and laws governing or relating to acoustic, magnetic, and electric action.

I.

Acoustics.

Acoustics is that branch of natural philosophy which treats of the physical nature of sound, and the laws of its origin, propagation, and effects.

Sound may be considered as a physical, or as a physiological phenomenon.

Considered in the physical sense, it is a particular vibratory motion in ordinary matter.

Its existence implies that the body whence the sound proceeds has been thrown by some means into a state of agitation or tremor, which consists of a vibratory or

to and fro motion of the component particles of the sounding body.

Considered in the physiological sense, sound is a sensation, which through and by means of mechanical action in the organ of hearing, becomes finally perceptible in that portion of the brain where the capacity to receive such sensation resides.

At that point—passing beyond the domain of material science—we may say that mechanical energy—beginning in a condensation and rarefaction of air—passes into psychological effect, and becomes hope, fear, joy, sorrow, conviction, doubt — whatever else is the moral or intellectual result of certain spoken words, or other sounds.

In order that the ear may be affected and the sensation of tone evoked by any sounding body, it is necessary that there be interposed between that body and the ear, one or more intermediate bodies (*Media*) capable of molecular vibration; which shall receive such motions from the source of sound, and transmit them to the ear.

The air around us forms the most important medium for the communication of sounds to our organs of hearing; in fact were the air devoid of this property, we should practically be without the sense of hearing.

All matter is in greater or less degree capable of taking up air vibrations resulting from sound, and transmitting them molecularly so that they may be perceived through the last medium by the ear. The approximate and specific cause of any vibration which the ear can recognize, is the condensation and rarefaction of the air lying against the tympanum.

Regarding the point at which the air receives the impact of the movement of the vocal organs, as a point of explosion, we have, first, a condensation or crowding together of the infinitely minute particles composing the air; followed immediately by a rarefaction, which is the return of the air particles as

nearly as possible to their former relative positions. This return is due to their own automatic and elastic action. Having been crowded together more closely than is most natural and convenient, they seek to withdraw from each other and relieve their abnormal mutual pressure. The two movements involved in this action constitute what is called an "air vibration;" which is, the movement by an air particle (or a great number of air particles in succession) forward to an extreme point—that is to say, until the motion is overcome by the resistance of the particles in front. At this juncture the particle commences to return along its course; and in due order all the other particles of the mass to which it has communicated its motion do the same. In the beginning and in the whole of its journey—in the case of simple tones—the particle moves by what is called pendular motion, that is to say, as a pendulum moves. A pendulum at rest hangs perpendicularly from a support. Let us suppose it to be displaced by the hand from that point of rest to a point in its arc and then allowed to swing. It will swing with constantly increasing velocity until it reaches and passes its former point of rest, and will then begin to climb to the opposite end of its arc with constantly decreasing velocity of movement. At that place all power to move further forward (against the resistance of the natural laws which seize upon it and seek to hold it) ceases, and it returns; beginning its return journey, at a minimum velocity which is constantly increased, until it again passes the middle of its course at a maximum velocity; going on with a diminishing velocity until it reaches the opposite end of its arc; from which it again returns, continuing that course so long as the power which gives life to its motion is effective. Attributing this same movement to an air particle (the actuating cause of whose motion may be considered to have ceased after one effort), we shall find the

air particle returning to the place whence it started ; arriving at that place with a maximum velocity ; passing it as a pendulum passes its point of rest ; reaching another point which may be spoken of as the extreme point of backward movement, where it is by the same causes stopped and started on its return to its point of rest.

This is sound in its physical character.

When the sound comes to be appreciated *physiologically*, the ear recognizes in it a variety of things.

First, it recognizes pitch :—the sounds may be high or low in any scale of sounds, such as the musical gamut.

Second, the sounds may be loud or soft.

Third, they may be the sounds of a musical instrument ; of a bell ; of a human voice ; of a human voice with varying or uniform tones ; of one word, or of another word. Thus, it may be "you," "I," "they," "horse," "cow," or any one of an infinite variety of vocal utterances.

These differences arise from differences in (1) the extent, (2) the number, and (3) the character of vibrations made by the air particle in obedience to the sound-producing cause ; that is, whether they be of pendular, or irregular form.

The *pitch* of the sound will depend solely upon the number of vibrations which the air particle makes to and fro in a given time ; the unit of time ordinarily taken being one second. The pitch will not in any degree depend upon any other condition or circumstance, however different may be the sound-producing causes ; thus, whatever substance causes an air particle to vibrate 256 times in a second will produce a tone, the pitch of which will be middle C, whether the sounding body be a piano, a violin, the human voice, or any other sonorous cause of vibration. The *rate* of vibration, therefore, controls the pitch.

The loudness or intensity of the sound will be determined by the extent (called amplitude) of the vibration.

Quality, or *timbre*, is the third effect by which the ear perceives the difference between different sounding bodies. This sensation is hypothetically imputed by physicists to the manner in which the compounded vibrations have been performed. Thus the movement may have been strictly pendular, beginning at a minimum; passing by uniform increase to a maximum; and thence by uniform decrease to a minimum; then returning with the same proportionate degree of velocity, etc. Or, the journey of the air particle may have begun with an initial maximum velocity, as is the case with every sudden, explosive sound. It may have proceeded with that velocity for a short distance, and then have been restrained or held back; and afterwards moved forward with an accelerated velocity. It may have continued its journey with a constant direction forward, or it may have returned for a certain time and distance upon its course, and then taken up the forward journey again. In short, an infinite variety of movement may—according to the hypothesis—have taken place in the manner in which the air particle gets to and from its point of rest over a definite length of journey within a fixed time.

Helmholtz Sensations of Tone, second English edition, by Alex. J. Ellis, London, 1885, p. 19, says:

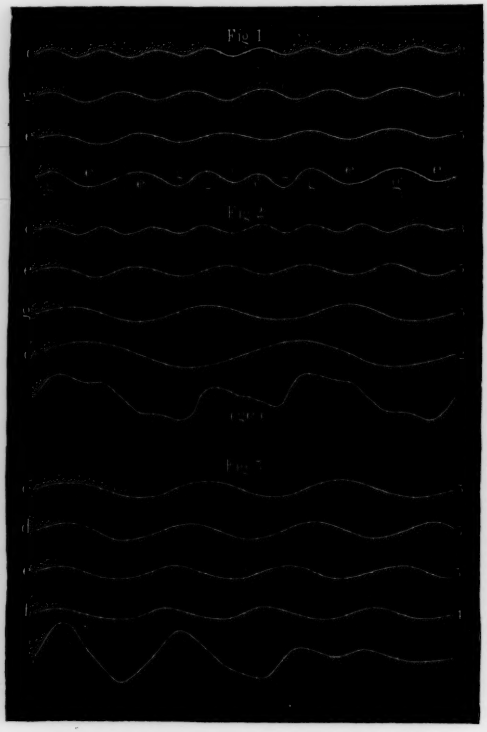
> "On inquiring to what external physical difference in the waves
> " of sound the different qualities of tone correspond, we must re-
> " member that the amplitude of the vibration determines the force
> " or loudness, and the period of vibration, the pitch. Quality of
> " tone can, therefore, depend upon neither of these. The only pos-
> " sible hypothesis, therefore, is that the quality of tone should de-
> " pend upon the manner in which the motion is performed within
> " the period of each single vibration."

Upon this hypothesis rests, therefore, the assumption at present universally made and accepted in the scientific world, for purposes of scientific reasoning, that the

quality or *timbre* of sound, or that which enables distinction between different sound-producing causes, to be recognized by the ear, arises from, is dependent upon, and truly represents, certain assumed or postulated eccentricities of conduct by the air particle while engaged in performing a certain number of journeys, of a certain length, within a certain time. Upon this Mr. Bell forms a similar *hypothesis as* to electrical action, and draws a conclusion that the electrical current undulates.

And this conclusion—built up, hypothesis upon hypothesis—he has patented.

When more than one simultaneous tone or sound acts upon an air particle it produces a compromise in the vibration.This is called a resultant vibration, and is the algebraical equivalent of all the others. Mathematicians represent it as well as the movement of the vibrations which compose it, by curves.*



Reis curves of three and four tones sounded simultaneously—and the combination or resultant curve in each case.

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* A sound wave is a certain definite succession of air particle movements, propagated from one particle to another, and so on.

For greater accuracy and fullness on this subject, we may refer to the evidence of complainant's expert, Prof. Cross (Mol. Rec., p. 97 *et seq.*):

The nature and cause of quality in sound, and the means by which it produces an effect upon the sensatory capacity of man being understood in a similar manner by all those who accept the wave theory of motion; it seems to be material now to consider *When these ideas had their origin.* Or, more specifically, whether they had developed so as to be a part of the common knowledge of scientific men prior to 1861, when Philipp Reis published his first article expounding these subjects, and explaining his apparatus for the transmission of sound.

Some signs of effort appear throughout the testimony of Prof. Cross, and in the arguments of counsel for the complainant in some of the cases in the Circuit, to date this knowledge from the year 1863, when the famous book of Helmholtz above cited was published; and from that fact to interpret the writings of Philipp

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To determine the extent of any particular series of air particle vibrations which go to constitute one wave, is to determine its length. To do this, we first determine the rapidity of vibration of the sounding body. Thus, imagine a tuning fork vibrating in free air 384 times in a second. At the end of a second from the time it commenced its vibrations, the foremost wave would have reached a distance of 1,120 feet in air of a temperature of 15°C; that is, the sound would have been heard at that distance. In this distance, therefore, are embraced 384 sonorous waves. Dividing 1,120 by 384 we find the length of each wave to be about three feet. The waves generated by a man's voice in common conversation are from eight to twelve feet; those of a woman's voice are from two to four feet in length. In air of a definite density and elasticity a certain length of wave always corresponds to the same pitch.

Tyndall on Sounds, D. Appleton & Co., 1884, pp. 96, 97, 98.

Reis upon an assumption that he was in 1861, ignorant of quality in sound.

That this is not a correct supposition will appear from the following:

II.

History of "Quality" as a Concept of Science.

The famous Thomas Young in "Young's Lectures on Natural Philosophy," published 1807, Vol. 1, p. 388, says:

"Such is the delicacy of the organs of hearing in the perfect "state, that we readily distinguish not only the frequency of the "vibrations of a sound, whether constant or variable, and its loud- "ness or softness, but also the *quality* of tone, *depending on the law "which governs each separate vibration, and which constitutes the differ- "ence between instruments of different kinds*, or different instruments "of the same kind, or even the same instrument differently em- "ployed."

P. 401: "Musical instruments * * * have a peculiar character of "tone * * * since their secondary harmonies are in different "proportions."

P. 402: "Of simple wind instruments, in which the quality of the "sound is determined by the vibrations of the air, the principal are the "syrinx, the flute, the flageolet, the diapason organ pipe, whether "open, stopped, or with a chimney, the humming top, and the "cavity of the mouth in whistling, or in playing on the jews- "harp.

Vol. 2, p. 84: "But there appears to be little or no difference in "the simple sounds excited in various manners, this variety aris- "ing principally from a combination of secondary sounds. The "*form of curve*, &c. * * * "

Upon page 546 of the same volume the term "*Form* of the harmonic curve," occurs three times.

Vol. 2, *Ibid.*, p. 550, in speaking of the office of the various parts of the organs of speech, Young says that they

"Variously affect the laws of the motion of the air in each

" vibration; or, according to Euler's expression, the equation of " the curve conceived to correspond with this motion, and thus " produce the various characters of the vowels and semi-vowels."

Vol. 2, p. 565: "Thus the harshness and disagreeable quality of " a single sound may also upon a more nice examination be some- " times found to consist in a want of harmonious proportion in " those secondary notes which generally enter into its composition. " This quality of sound, sometimes called its tone, register, colour " or *timbre*, might be considered as a fourth component part of " music; it depends on the law by which the parts of the sounding " body, and the particles of the air are governed with respect to the " velocity of their progress and egress in each vibration * * * " all this relates to the *quality* of sound. * * *"

Pierce's Natural Philosophy, James Monroe & Co., Boston, 1836:

(Pp. 65, 66, Vol. 2.) "In musical sounds there are three principal points of distinction—the pitch, intensity and the quality. Of these the intensity depends upon the violence of the impulses, the *quality* on the *law which regulates* the excursions of the molecules of air originally set in motion."

(P. 76.) "Any number of the different modes of vibration of which a cord is susceptible may be going on *simultaneously*, or may be, as it were, superposed on each other."

(P. 77.) "The ordinates of the curve into which the cord at any moment forms itself in virtue of the compound vibration will be the same (algebraically understood) of the ordinates it would have in virtue of each simple one separately."

(P. 78.) "The production of harmonic sounds on cords and their division into aliquot parts was first noticed by Wallis in 1673."

(P. 97.) "If the stream of air be increased in strength the pipe will yield the octave and harmonics of the fundamental note, forming the series 1, 2, 3, 4, etc."

In "Silliman's Principles of Physics," edition of 1866 (entered for copyright 1860), p. 267, we find these ideas clearly stated as follows:

" *Quality* is that peculiarity in sound which allows us to dis- " tinguish between sounds of the same pitch and the same intensity. " Thus the sound produced by the flute and clarionet are at once " distinguishable. The quality of the sound of instruments appears " to depend not only on the nature of the sonorous body and the " surrounding bodies set in vibration by it, but also on the form

" and material of the instrument; and probably also *on the form of* " *curve or vibration.*"

In "Dictionary of Science, Literature and Art," by Brande & Cauvin, London, 1852, it is said:

" The *quality* of sound (the *timbre* of the French authors) is less " easily explained. It probably depends on the greater or less ab- " ruptness of the impulses, or of the *changes* of velocity and density " of the strata of air between the two extremities of the wave.

" In 1843 there appeared in Poggendorff's Annalen (Bd. 59, s. " 513) a memoir under the title of 'Ueber die Definition des Tons " und die Theorie der Siren und Aehnlicher tonbildender Vorrich- " tungen.' The acoustic propositions which this paper maintains " on this memoir can be briefly stated in the following laws:

" Our ear experiences the sensation of a single *simple* tone from " those vibrations only, in which the particles of air move in a " direction perpendicular to the drum of the ear, to and fro, *like a* " *pendulum*, with a simple harmonic motion.

" The ear resolves every other kind of motion into a *series* of " pendular vibrations, corresponding to which it perceives simul- " taneously a series of tones.

" Every sonorous body emits, besides the deepest, strongest, " the fundamental, tone, higher tones or over-tones, whose vibra- " tion numbers are twice, three times, &c., as great as that of the " fundamental. Klang is the united sounding of simple harmonic " tones.

On these definitions of tone and Klang, were founded Helmholtz's beautiful acoustic researches which are collected in his book called "Sensations of Tone," above quoted, originally published in Germany in 1863.

In 1849 Helmholtz published in Poggendorff's Annalen, Bd. 108, a paper on the characteristics of the vowels in which he says:

" A musical tone is produced by uniformly repeated periodic " motion of the air in equal and sufficiently small intervals of time. " Within each vibration period the motion is a matter of indiffer- " ence, provided only that the same motion which occurred in the " first period is repeated in all following periods.

" If the air particles during each single vibration move in ex- " actly the same way back and forth as the centre of gravity of a " pendulum with a very small vibration, we hear only a simple and " single tone whose musical pitch is estimated by the number of " similar periods which occur in a second. * * * I have in an

" earlier work on combination tones shown a method by means of " which one can bring about simple pendular form vibrations " of the air particles, or, if I may coin a term, simple air " waves." * * *

" But if the air motion during a vibration period does not obey " the law of the pendulum but some *other law*, one will, on properly " directing the attention, as a rule, hear *several* tones, even when " the motion of the air is brought about by a single sounding " body. * * *

" In all cases where such an air motion is not actually evoked " by different sounding bodies, it is only a mathematical fiction " that a number of simple pendular form vibrations of the air par- " ticles exist side by side.

* * * * * * * * *

" I am now going to investigate the consequences of Ohm's law " as respects the doctrine of character (Klangfarbe). * * * In " its physical aspect it has *long been known* that the *different form* " of the air waves within each single vibration period corresponds " to what our ear distinguishes as character (Klangfarbe), or " *quality*."

It is believed that this is the first instance in any important paper in which the term " form " was used in direct connection with the word " vibration ; " it having been chiefly used before in respect to the form of the graphical curve by which the action of the particle was expressed.

In " Die Fortschritte der Physik, (p. 21 of the pamphlet entitled " Reis and Bourseul Publications," submitted by complainants, with the records), **O**., p. 2090, the editor, in commenting upon the annual report of the Physical Society of Frankfort-on-the-Main, for 1860 and 1861, containing the article of Philipp Reis, entitled " Telephony by means of the Electric Current," says :

" It was not possible thus far to reproduce spoken tones (Ton- " sprache des Menschen) with a distinctness satisfactory to all ; the " consonants are for the most part distinctly reproduced, the " vowels not in the same degree. The author attempts to explain " this imperfect reproduction of the vowels by saying that the ap- " paratus reproduces the vibration to a certain extent indeed with " proportionate, but also reduced strength, and the ear can no " longer satisfactorily discern the relation of the proportionally

"*great* vibrations which determine the pitch (Tonhöhe) to "the *small* vibrations on which *vocal quality* (vocal Farbe) de- "pends."

At p. 19, *Ibid.*, it appears that on November 16, 1861, Mr. Ph. Reis read to the Physical Society of Frankfort a "Statement of a new theory about the perception of chords and the *quality of sounds* [*Klang farben*], as a continuation of and *supplement to the lecture on the telephone.*"

While the preparation of this brief is going on, an English edition of the work of Urbanitzky, above cited, appears, containing what purports and is represented to be a lithographic *fac simile* of an original letter by Philipp Reis, under date of November 18, 1863, to F. J. Pisko, author of the "Die neueren Apparate der Akustik," Wien, 1886, in which he says:

"How is it that the tympanum of our ear can reproduce all tones with their *quality* (Klangfarbe), accords," etc.?

See App. No. 1.

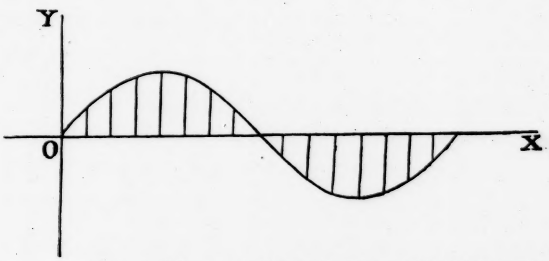
III.

DIFFERENT VIBRATIONS AND THEIR CURVES.

Simple Sounds.

A simple sound is one which generates an air-particle motion of strictly pendular vibration.

The following is a graphical representation of the vibration due to a simple sound:



See evidence of Prof. Cross Mol. R., 98, for explanation.

There are very few simple sounds in nature, and al most every (single) note of a musical instrument will be found to consist of several tones, which are called respectively "fundamental tones," and "overtones" or "partial tones."

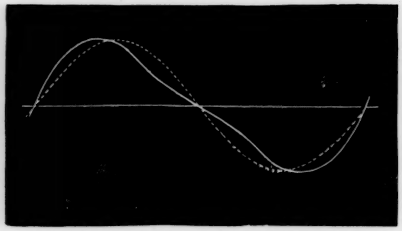
These overtones are all higher in the scale than the fundamental tone, being related to it by certain degrees called "harmonic."

Whenever a sound is composed of more than one tone, it begins to have *quality.*

(The expression of that QUALITY is in the FORM. *Thus the use of the word "form"* by Mr. Bell *in his patent* was proper and necessary in respect to the musical tone—*the tuned reeds* which he proposed to use in *multiple telegraphy.*)

A fundamental sound and its harmonics—which taken singly, are each, simple sounds with a pendular vibration—by their intermixture constitute a complex sound, whose vibrations cease to be pendular, and take a form more or less complicated. Each of these compounded vibrations is composed, firstly, of one vibration of the fundamental sound; secondly, of two vibrations of the octave; thirdly, of three vibrations of the twelfth; fourthly, of four vibrations of the double octave, and so on. The *general form* of the curve which represents this compound vibration is determined

by the fundamental sound; but the harmonics make its *contour* shrink and swell by *their* vibrations. In the curve shown below, the dotted line represents the curve of the fundamental sound, and the white line the curve resulting from the addition of the octave. It is a curve of this species which characterizes the timbre or quality of a compound sound; it changes form according to the relative intensity of the harmonics; but the number of the great curves or periods is always the same, and for this reason the pitch of the mixed sound is that of the fundamental note.



Radau's "Wonders of Acoustics," Charles Scribner's Sons, 1886, p. 187.

The dotted line shows the curve of the fundamental alone, and the solid line the combination, or resultant curve of the fundamental and octave, sounding together.

IV.

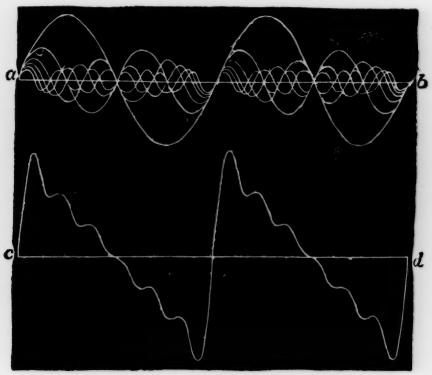
Compound Tones.

When several fundamental tones with their related harmonics are simultaneously sounded, we have what is called a "chord" in music. The increased complexity resulting from such simultaneously sounding tones makes the quality of the compound sound more

marked than the quality of any simple fundamental tone; requires a *higher degree of capacity in the ear* to separate the sounds or to realize their harmonious relations; and if the question be of transmitting the sound by any mechanical substitute for the air, demands from the *mechanism a higher degree of capacity*,—but still only a difference in degree.

Spencer Case, pages 106–114; Dowd Case, pp. 391–404; Dolbear Case, pp. 79–89; Molecular Case, pp. 91–103; Clay Telephone Case, pp. 116–126.

The following plate of curves known as Mayer's Harmonic Curves



represent at *a b* the separate curves of six simple sound waves, being the sound waves of a fundamental and its overtones. The motion which an air particle will actually take up under these differing influences is represented by what is called the "resultant curve," shown in the same plate at *c d*.

The resultant curves of several musical notes sounded at the same time are exhibited at pp. 1412–13 and ex-

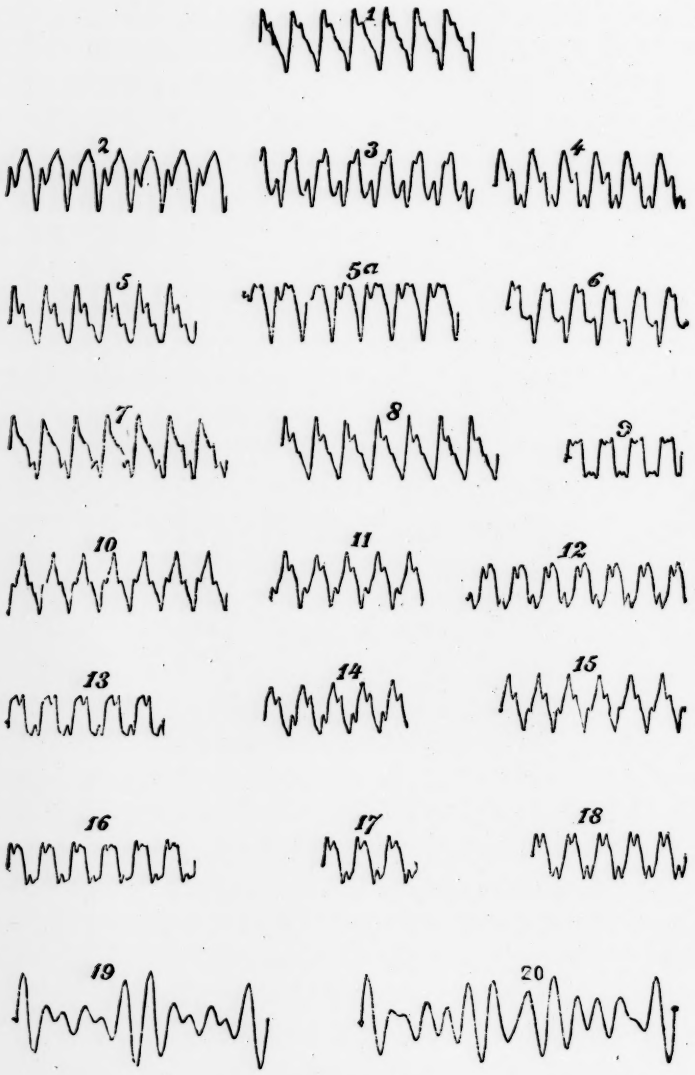


Plate 2

plained at p. 565, Mol. R., and the single curves and resultant curves of three different notes sounded at the same time are shown by Philipp Reis in the drawings accompanying his paper on "Telephony by Means of the Galvanic Current," at page 762, Mol. R., **O.**, p. 2046. The broad lines at the bottom of Reis's diagram—*egc*, *ceg*, *gce*, &c.—show the resultant, or compromise curve.

V.

Articulate Speech.

The most complex and variable of all sounds is that of articulate speech.

Articulate speech is a combination of vowels and consonants following each other in a certain order or system prescribed by the law of language. We know that vowels are simple combinations of musical notes of certain pitch and strength for each vowel. We know that words are formed by producing vowel sounds with certain consonantal adjuncts which are subject to variation in tone by change of the position of the cavity of the mouth and the lips, which act as resonators, with the effect of enforcing certain overtones and muffling others.

Speech consists in the first place of the emission of sounds having different characters—peculiar timbre—to wit, vowels. The second element of human speech consists of consonants, which are not persistent tones, but modes of beginning or finishing the vowel tones by a sort of explosion; that is, by a movement of the air comprising at the most a very small number of vibrations, of different form from those of the vowels which they modify. When a consonant begins a word, such explosion precedes the musical sound of the vowel and ceases as soon as the vowel sound has taken place, as

in ba, be, bi, etc. Or it terminates the vowel sound by a final motion of the lips as in ab, at, ar, etc. The consonants in no way depend upon or are affected by the pitch of the vowel sound which they introduce and terminate. The great variety in human voices, and even in the same voice in pronouncing the same word under different circumstances may demand from any mechanism contrived to transmit the effect of the voice a degree of development in mechanical capacity—beyond what will be requisite for the transmission of musical notes with their less complex quality; but still, *only a difference in degree.*

The method by which each kind of sound will be transmitted *telegraphically*, will be "by causing electrical" variations, oscillations, or "undulations, similar in form to the vibrations of the air accompanying the * * * sounds" (Bell's 5th Claim).

The testimony of complainant's expert, Prof. Cross, is clear on these points:

"47 x-Int. Do you understand that an apparatus which is capable of transmitting sounds *other* than vocal sounds, not articulate words, by causing electrical undulations similar in form to such sounds *would embody the invention described in said fifth claim?*"

"Ans. I DO."

The American Bell Telephone Company vs. Spencer, p. 129; **O.**, p. 3954.

"45 x-Int. At that time was the art of transmitting musical tones, including vocal musical tones, by electricity known?

"Ans. The art of transmitting the characteristic pitch of musical sound, including the pitch of a sound produced by the voice, was known. The transmission of all the characteristics of *any* sound—its intensity, its pitch *and* its quality—was not known.

"46 x-Int. Don't you, in your last answer as to what was not known, describe an art which, if known, would have been the art of transmitting articulate speech?

"Ans. The theoretical knowledge of the manner in which the one could be done would, I think, necessarily involve the theoretical knowledge of the way in which the other could be done. The *practical realization of an instrument* which could transmit the three characteristics of pitch, intensity and quality of a musical

sound would *not necessarily* involve the *practical realization* of the transmission of articulate speech."

Complainants' Evidence, Mol. R., p. 129.

"57 x-Int. Suppose a Reis transmitter of the form shown on page 10 or page 13 of said Prescott's work" (being the form known as the Reis-Legat transmitter) "is spoken into so softly as not to cause any actual separation of the electrodes, will not such transmitter act so as to vary the electric current so as to produce in such current an undulation corresponding in form to the sound spoken into such transmitter?

"A. When operated in the manner described, the transmitter figured on page 10 will do this.

"58 x-Int. In your opinion will the efficiency of the Reis transmitter vary with the *kind of material* which is used in the electrodes?

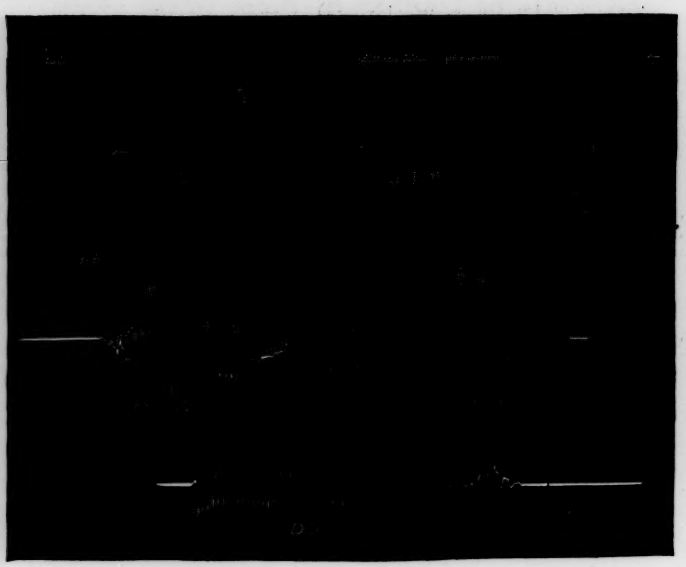
"A. For use as a Reis transmitter, the efficiency is doubtless *much influenced by the nature of the electrodes*, which is well known to be the case in all circuit-breakers.

"59 x-Int. Suppose a Reis transmitter of the form shown on page 10 of said Prescott's work is spoken into so softly as not to cause any actual separation of the electrodes, will not the transmitter produce in the electric currents in the line wire a series of undulations corresponding to the quality of the sounds spoken into such transmitter; I use the term quality in the sense in which you have used it in speaking of the characteristics of sound vibration?

"A. *It will.*"

The American Bell Telephone Company vs. Spencer, p. 131; **O.**, pp. 3956–7.

The curves due to certain articulate sound vibrations are shown by the well known "Brown University Curve" of Prof. Blake (Mol. R, pp. 102–3; **O.**, pp. 129–130).



The citations above, and the references to Reis instruments, have been made at this place in advance of any description of those instruments, in order to sustain the general proposition, which is now made:

That any variable resistance instrument, in transmitting telegraphically a simple sound composed of a fundamental and its overtones—or, simultaneous musical tones with their respective overtones — will NECESSARILY operate by the same process or method as the same or another instrument, when transmitting telegraphically the higher complexities of human speech. This method will necessarily be that which has been patented by Mr. Bell under the terms "by causing electrical

undulations similar in form to the vibrations of the air accompanying the * * * sounds"—whether the hypothesis expressed and patented in those terms be correct or not. Between these different uses, and the operations required to accomplish each, will be found NO NEW LAW; AND NO NEW ART; but, only, DEGREES OF MECHANICAL adaptation or development in apparatus.*

In considering hereafter the state of knowledge of Charles Bourseul and Philipp Reis, it must be assumed that they were acquainted with the scientific facts published to the world at the date of their respective writings; and that they each knew especially that *quality* in sounds is caused by the manner in which vibrations of a fixed amplitude and rate, are executed.

Imputing to them such knowledge, we may take our next step towards the evolution of the telephone, by the consideration of (1) a few known facts concerning magnetism and electricity and the exhibition of vibrations to the eye, by the plates of Chladni (or membranes) (see Tyndall on Sound, pp. 169–172); (2) the published words of Reis and Bourseul; and the mechanical attempt of Reis to realize a practical telephone. These will show them to have possessed knowledge that the transmission or reproduction of any

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* In the N. J. McDonough case (read in this case by stipulation) all the differences between the Reis and the best modern microphone transmitter were collated in a question to Prof. Cross, and he was asked if he found any of these differences in the Bell patent. He answered:

"A. I find no specific reference to any one of them." He added—afterwards withdrawing it, though not on any ground affecting the correctness of the statement—"I *wish to observe, however, that these differences in themselves are mechanical in their nature.*" (Bruce Pub. 478)

sound, simple or compound, *in or through any of the media to which nature has given capacity to transmit sound vibrations*, must be by means of vibrations similar in amplitude, rate and form to the vibrations immediately accompanying the sound: and this, too, whether the vibrations be to and fro motions of matter, or plus (+) and minus (—) *changes in the strength of an electric current:* and whether the energy of the air waves themselves is the actuating cause (thus in a sense propagating itself), or is imitated by some other mechanical action.

The knowledge of this law is claimed to have been given to the world by Mr. Bell; and that erroneous idea is the sole foundation for the broad patent claim under which the rest of the world has heretofore been excluded from practicing an art—all the principles and conditions of which were known and published to the world before the year 1864, and the complete commercial realization of which, awaited only a good mechanic to make a suitable apparatus and a Boston syndicate to give it a favorable introduction to the world.

VI.

Magnetism.

Magnetism need be no further defined than to say that it is a state or condition of certain bodies in which they have the power to attract or repel other bodies.

The state of magnetization may be permanent or temporary.

According to the most approved views, magnetization is nothing more than a determined position of all the molecular magnets composing the body.

A piece of iron is said to be in an unmagnetized con-

dition when the molecules assume various or mixed directions.

A variety of substances are subject to be put in a state of magnetization. Of these it is necessary in this case to refer only to metals contained in the machines or apparatus used in telephony.

Steel possesses the property of retaining a magnetic charge permanently, when once it has been charged.

Annealed iron loses its magnetism upon the withdrawal of the magnetizing influence.

Magnetism has circulation somewhat analogous to that of the electric current.

The magnetism of a permanent magnet has polarity, *i. e.*, direction of its circulation according to the direction of the influence originally creating it. This polarity is therefore fixed.

An electro-magnet, *i. e.*, soft iron bar temporarily magnetized by the presence of an electric current—has a polarity, according as the electric current may be in one or the other direction. This polarity is, therefore, variable. Magnetism cannot be insulated, but will pass through non-conductors of electricity, and exert its influence on a body capable of magnetic induction.

The magnetic influence is exerted at the extremities of the magnetized bar.

These extremities are termed the *poles*, and for the sake of distinction, are termed *north* and *south* respectively.

The magnetic influence given out from the poles is in the direction of lines radiating in every direction.

The space within which these lines radiate is technically termed the *magnetic field.*

The magnetism within this field is termed *free magnetism* in contradistinction to that retained within the magnet. An *inducing* or *inductive body* is any metal capable of becoming magnetic, or in other words, which has the power of being attracted by a magnet, such as iron, steel, etc. An inducing body brought within

a magnetic field will become magnetic, absorbing more or less of the free magnetism according as it may have capacity.

The magnetic lines will focus on such inducing body, and are thereby diverted from their normal position towards that part of the *field* entered by the inducing body.

The diverted force will resume its normal position when the disturbing body is withdrawn.

This movement of the force is termed for easy reference a *disturbance.*

Magnetism and electricity are intercontrovertible; that is to say, magnetism will generate electricity and electricity will generate magnetism.

VII.

Electricity.

No definition of electricity will be attempted here. It is known only by the phenomena attending its production and employment. It is believed that all which can be truthfully said in a general way is said by Prof. Cross, in his deposition in the case of the Speaking Telephone Interferences (Patent Office), Vol. 3, pp. 103–111, that

> "We have every reason to suppose that sound, radiant heat (so "called), and light are phenomena of wave motion. Regarding the "nature of electricity we are less certain."

And

> Cross-Int. 49, "Are these modes of motion always the same in the "instances of electricity and sound?
>
> "Ans. In the case of sound, the motion is always a wave motion. "*As to electricity, I do not know.*"

Our remarks upon electricity, therefore, will be

limited to brief references to the manner of producing certain effects which are attributed to it.

Two modes only, of generating electricity need be referred to.

First. Electricity is generated by chemical action, of a conductor or an inductive body, such as a metallic diaphragm in a magnetic field; such as the action of acid upon zinc.

Second. Electricity is also generated by the motion of inductive bodies in presence of magnets or conductors.

The first is called voltaic and the second is called magneto-electricity.

Voltaic electricity is made available by uniting the two poles of a cell with a conducting wire of any length.

Magneto-electricity may be made available by coiling the conducting wire in a great number of convolutions within the magnetic field, usually around one end of the magnet, so as to be in position to receive the electrical influence effected by the disturbance of the magnetism of the magnet.

The polarity of a *voltaic* current *remains constant* but is determined by the particular element—in the battery—with which the conducting wire is connected.

The polarity of a *magnetic* current is constant *only so long* as the inductive body may be approaching or receding from the pole of the magnet; it is in one direction on the approach and in the opposite on the recession.

The current from a voltaic battery of a given power will have its strength affected by the resistance of the circuit in which it is circulating. If that resistance is increased, the current will be weakened; if it is diminished it will be strengthened. Variable resistance is caused by changing the length or the cross-section of a conductor.

A variable resistance transmitter is one in which the

change in resistance is produced by the change in cross-section, under the varying pressure resulting from sound waves.

Voltaic electricity may be converted into induced electricity through the medium of an induction coil.

An induction coil is an electro-magnet with an additional coil of insulated wire wound upon the first coil (as usually made), but in no metallic connection with it. The first is termed the primary, and the second the secondary coil.*

All interruptions, whether total or partial, of the voltaic current in the primary coil, induce currents of corresponding variation in the secondary coil, and these are increased by the magnetization and demagnetization of the iron core.

When the iron core of an induction coil is being magnetized the current induced in the secondary coil is in one direction, as when an inductive body ap-

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* Electric induction was discovered by Faraday in 1831, in the following manner: A long copper wire was wound around a wooden cylinder, and between the turns of this wire, and insulated from them, a second wire was wound in the same manner. The ends of the first wire were connected with the poles of a powerful battery; the ends of the second wire were connected with the galvanometer. Whenever the current was sent through or interrupted in the first or primary wire, a current was also generated in the second or secondary wire, and was indicated by the deflection of the galvanic needle. The induced current which was generated by making or breaking contact in the primary circuit was sent through a coil wound round some steel needles, and it was found that the steel needles became magnetized: the position of their poles depending upon which of the induced currents was sent through the coil. These experiments proved that the induced currents are generated in a conductor forming a closed circuit when a current passing through a neighboring conductor is made or broken or has its strength altered; and that the directions of the currents induced on making or breaking contact are opposite to each other.

Induced currents are produced when a conductor through which a current flows is brought near to, or taken away from a second conductor forming a closed circuit.

proaches the pole of the magnet. When it is being discharged of its magnetism the current induced in the secondary coil is in the opposite direction, as when an inducing body recedes from the pole of the magnet. Thus a voltaic current of *constant* polarity but of variable strength, gives rise to an induced electric current of *alternating* polarity; the strength of this electric current thus generated being proportional to the variation of the voltaic current.

Thus, we see that in 1854–1864, the state of knowledge in acoustics, electricity and magnetism included certain fundamental laws.

In Acoustics.

1. That sounds are propagated by vibrations of matter.
2. That the loudness of any sound is determined by the amplitude of the vibration, or the distance through which the air particle moves to and fro.
3. That the pitch of a sound is determined by the number of times in which an air particle will traverse this amplitude in a given time.
4. That simple sounds give simple periodic and regular vibrations.
5. That all sounds are compound whose vibrations are the result of simultaneous action of several simple tones, whether resulting from one or from a number of sounding bodies.
6. That " quality " pertains to, and is predicable of, all compound sounds—of which articulate speech is one class; and that the air particle in obeying the impulses of the compound sound-producing causes, no longer makes the motion due to any one of them, but another motion which is a compromise upon, and the algebraic sum of all their varying—and perhaps conflicting impulses.

7. That quality is expressed and represented by something in the manner in which the vibration is made—different from the amplitude and rate, but included within the amplitude.
8. That air vibrations can be taken up and reproduced by a plate or diaphragm.

In Electricity and Magnetism.

As will appear by the references to the writings of Bourseul and Reis now to be cited, it was also known before 1864, and substantially published to the world :

9. That plate or membrane vibrations, derived from air vibrations, can be made to produce in a conductor, electrical changes corresponding to the air vibrations :
10. That by the use of an electro-magnet and a second plate, the electrical vibration can produce another air vibration in another place corresponding to that which accompanied the original sound : or in other words, that vocal and other sounds can be transmitted " telegraphically, by causing electrical undulations similar in form to the vibrations of the air accompanying the * * * sounds " (Bell's 5th Claim).
11. That apparatus capable to perform this work was devised, publicly used, and descriptions thereof—sufficient in law to establish an anticipation—were made, prior to the year 1874, when Bell claims to have conceived the idea of his magneto telephone.

With these observations upon the state of knowledge and the arts before 1861, we may next give attention to—

FOURTH.

First Conception of the Art of Transmitting Speech by Electricity.

The first published conception of any plan by which speech might be transmitted over an electric conductor and reproduced, occurs in "L'Illustration Journal Universel," Paris, 1854, in the form of a communication by Charles Bourseul (Reis and Bourseul Publications, page 2), **O.**, p. 1853, in which, after brief reference to the principles of electric telegraphy; the function of the electro-magnet in it; its achievements in the creation of audible signals, etc., he says:

"It would seem impossible to go beyond this in the region of "the marvellous. Let us try, * * * I have asked myself, for "example, if the spoken word itself could not be transmitted by "electricity; in a word, if what was spoken in Vienna may not be "heard in Paris? The thing is practicable in this way:

"We know that sounds are made by vibrations, and are made "sensible to the ear by the same vibrations which are reproduced "by the intervening medium. But the intensity of the vibration "diminishes very rapidly with the distance, so that even with the "aid of speaking tubes, trumpets, it is impossible to exceed nar- "row limits. Suppose a man speaks near a moving disk, suffi- "ciently flexible to *lose none*" (or, as we might say, nothing) "of "the *vibrations of the voice;* that this disk alternately makes and "breaks the connection with a battery; you may have at a dis- "tance another disk, which will simultaneously execute the same "vibrations.

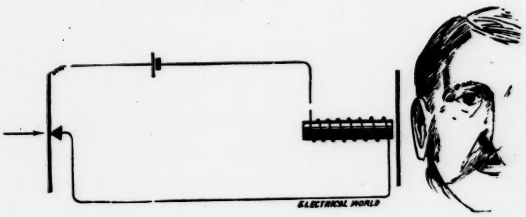
"It is true that the intensity of the sounds produced will be "variable at the point of departure at which the disk vibrates by "means of the voice, and constant at the point of arrival, where it "vibrates by means of electricity; but it has been shown that this "does not change the sounds. It is, moreover, evident that the "sounds will be reproduced at the same pitch.

"The present state of acoustic science does not permit us to de- "clare *a priori* if this will be precisely the case with syllables ut- "tered by the human voice. The mode in which these syllables "are produced has not yet been sufficiently investigated. It is true "that we know that some are uttered by the teeth, others by the "lips, etc. * * *

"However this may be, observe that the syllables can only repro-
"duce upon the sense of hearing the vibrations of the *intervening*
"*medium*. Reproduce precisely these vibrations, and you will re-
"produce precisely these syllables. * * * I have made some
"experiments in this direction. They are delicate and demand
"time and patience; but the approximations obtained promise a
"favorable result."

In this paper—unpreceded by publication in any scientific or other work, or by any discovery or suggestion, so far as the records of this case or the researches of numerous students disclose—Charles Bourseul suggested not only an apparatus applicable for the conveyance of sounds, but a principle of operation which constitutes a necessary condition of the telegraphic transmission of speech. This condition may be stated in two forms: *First* (in his own language), "the syllables can only reproduce upon the sense of hearing the *vibrations of the intervening medium*;" In other words: the vibrations which the intervening medium brings to the organ of hearing must have been so controlled by the spoken syllable as to be made correspondent to its vibrations, —else the syllable will have failed in its designed effect; and, *Second*, (in the words of Bell's Fifth Claim), "causing electrical undulations, similar in form to the vibrations of the air accompanying the said * * * sounds." Both investigators had in view a common generic object, which was the reproduction, by means of the electric current of the vibrations which cause the sensation of sound.

The following is an ideal suggestion of Bourseul's plan, without working parts:



The art of reproducing in any manner (1) *vocal sounds,* (2) *other sounds, is* ONE "*art.*"

Bourseul had expressly in view the reproduction of such specific sounds as constituted articulate speech; and, considering all the difficulties, he declared as a controlling condition, that spoken syllables whether uttered under such conditions as to reach the organ of hearing through the air as a sole medium; or through the air, a movable disk, an electrical conductor and another disk,—as connnected and successive media,—could have their due and desired effect, only when the vibrations of the entire intervening media were substantially like the vibrations accompanying the spoken syllable.

The subject under discussion was, the doing this with an electric current and wire. That a transmutation of mechanical into electrical forms of action and back again would happen, was, therefore, a fundamental condition of every argument and statement.

That it would not be a transmutation, but a substitution, if anything was changed, went without the saying.

The capacity of the electric telegraph with all its known means and appliances was to be extended. The combination before his imagination included the idea of air vibrations which were (1) to move a movable disk, whose movements were (2) to actuate an electrical apparatus so as to set up electrical vibrations or change of some sort, which were in turn to be (3) the cause of mechanical motions in another movable disk, which

last motions were to be (4) the cause of aerial vibrations reaching to some listening ear.

In respect to all this operation only one absolute condition is suggested, which is that *unless* the operation can be so conducted as to *lose none of the vibrations* of the voice *anywhere* on the journey the attempt will be *unsuccessful.*

In other words, it was recognized and announced as a LAW, that the syllables could not produce their effect unless their vibrations were *reproduced* throughout *all* the intervening media—including, of course, the electrical conductor and current!

The suggestion attracted attention; and the manner in which it was understood by intelligent, popular writers is shown in an article published in "Didaskalia" (a magazine for intelligence, etc., Frankfort, a. M.), on the 28th of September, 1854 (Reis and Bourseul publications, p. 5) **O.**, p. 1857. In this article it is said—speaking of the laws governing the proposed operation—

"This magnet, the electro-magnet, can thus alternately attract or let go a movable plate. * * *

* * * * * * * *

"Could there now be invented a metallic plate which should be so "movable and pliable that it reproduces *all* the vibrations of tones "(*like the air*), and should this plate be so connected with an elec- "tric current that it should alternately make and break the electric "current *according to the air vibrations by* which it was affected, "it would thereby be possible also to arrange electrically a second "similarly constructed metal plate, so that it repeated simultane- "ously exactly the same vibrations as the first plate, and it "would then be exactly the same as if one had spoken in the im- "mediate vicinity against this second plate, or the ear would be "affected precisely as if it received the tones directly through the "first metallic wall."

We learn from a work of DuMoncel's (Expose des Applications de l'Electricite, Paris, 1856) that that compiler and electrician had been at one time unwill-

ing to give a place in his book on telegraphy to what he calls a "fantastic conception"* of a certain Mr. Ch. B. * * * who believes that we may yet be able to transmit speech by electricity. †

In the criticisms, and the praise (not unnaturally qualified under the circumstances) which this writer is finally constrained to give to what he regarded as a "fantastic conception," we find him declaring that

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* Count DuMoncel seems compelled, however, by the publication in other journals of this most brilliant and reasonable "fantastic conception" to notice it, and adds:

"But I ought to be true to the task which I have undertaken, "* * * and, therefore, I will here give the information which "the author has published up to this time on the subject."

Subsequently, in 1877, DuMoncel appears to have said:

"However this may be, the fact cannot be concealed that it is "Mr. Bell who is the inventor of the telephone, for there is a whole "world between a first idea and its definite realization. It is simply "because Mr. Bell has made the intensity of the current which "transmits the vibrations of the voice to correspond to the latter in "their amplitude and their changes that the problem has been "solved."

In a later edition of his book in 1879, again confessing that when Bourseul's article was first published he regarded it as a "fanciful dream," adding:

"Events justified this daring idea, and although it did not in- "clude the only principle which could lead to the reproduction of "articulate sounds, yet it was the germ of the fertile invention "which has made the names of Graham Bell and Elisha Gray "famous."

Later, in the same article, DuMoncel appears to quote from some writing or speech of Bourseul as follows:

"Reproduce at one end of the line the vibrations of air caused "at the other, and speech will be transmitted, however complex "the mechanism may be by which it is affected."

† A similar skepticism in science resulted in the denial to Reis of the privilege of having his first paper (read before the Physical Society of Frankfort in 1861) published in the great scientific record known as Poggendorff's Annalen; a failure to which the sympathizing friends of Reis impute much of the discouragement which fell upon him; and which, added to his want of resources, and ill-health, seemed to have impeded the full realization of his ambitious project (see Appendix 1, p. 383).

nevertheless Mr. Bell "is the inventor of the *telephone;*' and that the "fantastic conception" did not "include the only principle which could lead to the reproduction of articulate sounds."

The question whether Mr. Bell invented "THE *telephone*" will not be contested in this case upon the authority of anything said by Bourseul; but the statement that Bourseul's idea "did not include the only principle which could lead to the reproduction of articulate sounds will be seriously disputed. Upon that point the testimony of DuMoncel would have been more valuable had it been submitted to cross-examination.

We have to deal in this case *chiefly* WITH A CLAIM TO THE DISCOVERY OF A PROCESS, a vital part of which—as it has been interpreted by its friends and by the Courts, in the judgments appealed from—is (1) the creation by the energy of air waves, of electrical undulations similar in form to the vibrations accompanying a sound; (2) the use of such undulations in the telegraphic transmission of sounds.

These principles—as applicable to the transmission of sounds in general, and of the sounds of articulate speech specially—are, in a complete philosophical form, contained in the words of Bourseul, written in view of an ideal apparatus containing a battery, an electromagnet, movable disks and a line wire—and after considering them this Court *must determine their bearing upon a present broad claim* for those principles—or processes—*as a newly-discovered art.*

We are not saying that the apparatus suggested by Bourseul would have been an operative telephone, or that Bell's *apparatus can be anticipated* by any mere suggestion of another. Our argument has not yet advanced to the consideration of the telephone as a concrete apparatus. We are dealing with the first conception of *a principle;* its statement as *a problem*

whose solution was to be—a machine; and the subsequent grant of a broad patent for a *machine;—and along with it*, THE OLD PRINCIPLE!!

The object in dealing with it in this manner at this time is to prepare the way for the irresistible conclusion, which, as it appears to us, must follow from any fair-minded contemplation of all the facts in the history of this art, that the important and controlling feature of the Bell patent of 1876 is a claim to *this problem*, and to its solution, whenever, however, and by whomever it may be solved. We repeat, therefore, that Bourseul conceived and stated that the successful transmission of speech requires that the vibrations which primarily accompany the pronunciation of the syllables, shall be continued throughout "the intervening media."

When the medium under consideration is in part an electrical conductor, this statement contains an implied term that the electrical action, *whatever* its *nature* or *name* in science, is to *correspond faithfully* to the air vibrations by which it is produced, and which it is in turn to reproduce; and this is a *scientific fact*, or LAW OF NATURE.

This correspondence can be no further or more completely described than by saying that it is to be such, that the aerial and electrical impulses, movements, changes, perturbations, vicissitudes, transformations, whatever they now are, or in the developing terminology of science may hereafter be called, shall be *representable* mathematically by the *same curves;* and that the electrical actions shall be capable to prove their identity by reproducing the forms of aerial energy in which they had their origin. The suggestion by Bourseul that the current was to be made and broken is of no importance. It is an expression in advance of experiment, of a tentative judgment as to what kind of mechanical manipulation would produce those "electri-

cal undulations similar in form to air vibrations, &c.," which similarity in form by the *law* of his conception must be a condition precedent to the telegraphic transmission and reproduction of vocal or other sounds.

If he had devised an apparatus *incapable* to operate *except by make and break*, then the scope of his *philosophical idea* must have been limited by the purposely *limited functions* of his *device*. He might in making an apparatus to execute his intellectual conception of a process, have failed or succeeded. This—still assuming the theory of electrical action supported by the complainants—would have depended upon whether he meant by a make and break connection with the battery, a complete severance, or an incomplete and varied interruption. If he contemplated a complete severance, and had failed, he might or might not have realized practically that that was the cause of the failure. Upon his ingenuity as a deviser of expedients, or his skill as a workman, and not upon his conception of the principle or problem as a man of science would have depended his capacity to remedy his failure. His words show him to have been too well grounded in the knowledge of acoustical science, and of the general philosophy of physics; too acute, discriminating and judicious in his manner of looking at the operations of nature, ever to have been led to doubt or qualify his first fundamental and perfectly accurate conception that the sensations of sound, and specifically of speech, will be reproduced at any distance, if throughout all the intervening media the actions and operations in each field are made to correspond to certain air vibrations of which they are to be progeny and progenitor.

There are different ways of stating this condition without at all varying its meaning. Didaskalia says the current is to be made and broken "*according to the air vibrations;*" Bell says the current is to be made

into a form "similar to the air vibration;" which form requires that it should be broken whenever by the law of acoustics the motion of the air particle ceases.

(This last, as we can easily see, happens in every word at the end of a syllable. Every word consisting of more than one vowel sound has its periods of silence, due to the temporary cessation of air particle movement; without which cessation the sound would be continuous).

The telephone of to-day could not be better described than—in the terms of Bourseul—*as an instrument by means of which spoken syllables can reproduce, through correspondent vibrations of various intervening media, a distant effect* upon the sense of hearing, *equivalent to themselves.*

We have, therefore, in this publication, a statement of a LAW OF NATURE; compliance with which is indispensably requisite to the accomplishment of a certain result; and which law, when set in motion by accident or design, will, past all power of man to control it, produce its effect.

The *right to avail* of this law has been patented by Mr. Bell.

And thus we see the first step in the evolution of discovery of the new art of sound transmission, intelligently completed.

If, however, Charles Bourseul left anything to be desired by way of exposition of the process which nature supplies and imposes, that lack was supplied by a greater than he.

FIFTH.

Philipp Reis.

First Realization of the Transmission of Speech and other Sounds.

The "Didaskalia" article upon Bourseul, already quoted, was published in Frankfort in 1854, at which time it is understood Philipp Reis was a resident of that city or neighborhood, being at that time but 20 years old. In Reis' own account of himself we find no reference to this publication or indication that he had read it. Whether he ever read it or not, it is certain that he had several years before its publication entered upon the course of study and experiments afterwards described by him, with the purpose of transmitting articulate speech. These experiments consisted in an effort to create sounds artificially, as was at one time done by Helmholtz through the use of vibrating reeds; or as had been done by the well-known automatic speaker of Faber.

In now considering the instruments devised by Philipp Reis, including the so-called Reis-Legat instrument, (which, if not devised by him, was devised by Legat upon the principles declared and expressed by him,) we shall find benefit in looking at the problem historically, from the standpoint of young Reis himself, when, being between seventeen and eighteen years of age he undertook the study of the recondite subject of the production and transmission of vocal and other sounds by artificial means.

At this early age (in 1851) he set before himself this question:

"How could a single instrument reproduce the combined effect of all the organs occupied in human *speech?*"

The question took this form naturally, and because, no doubt, of the influence of a period then closing, during which the science of practical mechanics had achieved some wonderful results—which led those practicing it to believe there was no limit to the power of art to imitate the powers of nature.

The famous automaton speaking man of Faber furnished something with which to mislead the imagination of a young philosopher. Various more or less successful attempts had been made to build automaton figures which should perform the functions of men and animals. The wonders of the last century, were Vaucanson's duck, which fed and digested its food; the flute player of the same artist, which moved all its fingers and looked at them as they moved; the writing boy of the older, and the piano-forte player of the younger Droz who, after finishing his piece, rose and bowed courteously to the audience. All these were mechanical triumphs of art at the close of one epoch and the beginning of another, in the history of philosophy.

> Helmholtz's Interaction of Natural Forces, contained in Vol. entitled "Correlation and Conservation of Forces," D. Appleton & Co., 1885.

Not unnaturally young Reis attacked the problem of reproducing and transmitting speech from that side, by attempting to make something which would *speak;* and therefore he asked:

"How indeed could a single instrument reproduce the combined effect of all the organs *occupied in human speech?*"

The strength of his intellectual development and the power and clearness of his reasoning is indicated by the fact that finally in 1861 he was able to repeat to himself the question in another form:

"How is our *ear affected* by the totality of vibrations produced by the organs of speech all simultaneously active?"

This form of the question implied not an instrument which should *speak*, but one which should *listen!*

The one conception implied an extension of the *speaking* power until it should *reach the listener;* the other implied an extension of the *hearing* power until it should *reach the speaker!*

He was at the time a teacher of physics at the Garnier Institute, a school for boys, at Friedrichsdorf.. The few words from his pen which remain to science and history give evidence of an acute mind, a profound knowledge of physics, an upright, unimpassioned and truly scientific spirit, and, in a certain degree a lack of practical qualification to deal with mechanical difficulties, the overcoming of which by Edison, Blake and others (not Bell) constitute the second step in the development of the commercial speaking telephone of today. The first step required a clear conception of a general principle of philosophy which had at that time taken full possession of the scientific mind of the world, to wit: *That all forces of nature act and exist under certain laws of correlation which assume, that energy is indestructible, and that its forms are capable of mutual conversion.*

"Towards the close of the last century the human mind reached "the great principle of the indestructibility of matter. What the "intellectual activity of ages had failed to establish by all the re- "sources of reasoning and philosophy was accomplished by the "invention of a mechanical implement, the balance of Lavoisier. "When nature was tested in the chemist's scale-pan, it was first "found that never an atom is created or destroyed; that though "matter changes form with protean facility, traversing a thousand "cycles of change, vanishing and reappearing incessantly, yet it "never wears out or lapses into nothing."

Correlation and Conservation of Forces, D. Appleton & Co., 1885, introduction, p. ii.

"The present age has demonstrated that the same great prin- "ciple applies also to forces, and established a new philosophy con- "cerning their nature and relation. Among the specific conditions "or elements arising from this principle was this special one that

" mechanical motion, which is a motion of masses, may be trans-
" formed into heat or electricity, which was held to be a motion of
" the atoms of matter, while by a reversed process the motions and
" atoms, that is, heat or electricity, may be turned back again into
" mechanical motion. * * *

" These mutations are found to be rigidly subject to the laws of
" quantity. A given amount of one force was then known to pro-
" duce a definite quantity of another, so that power or energy, like
" matter, can neither be created nor destroyed; though ever chang-
" ing form, its total quantity in the universe remains constant and
" unalterable. That every manifestation of force must have come
" from a pre-existing equivalent force, and must give rise to a sub-
" sequent and equal amount of some other force."

Ibid., pp. xii., xiii..

The equivalency of these forces and the law of quantity implies that where the originating force is variable, the resulting force will be, in a degree precisely equivalent—variable. This knowledge must be assumed to have rested in the mind of Philipp Reis, as an intelligent, instructed and observing physicist and experimenter. These relations of the modes of energy were, at the time, currently known by the phrase "Correlation of Forces," but which Herbert Spencer prefers to call " Persistence of Forces."

" Their discussion formed a living element in the scientific litera-
" ture while they *occupied the thoughts* and *guided the investigations*
" of philosophical inquiries" (*Ibid.*, p. xiv.)

As already shown, in physical acoustics sound is vibratory motion of ordinary matter. It was a fundamental conclusion among physicists that " wherever continuing phenomena are rendered evident in *two* different *points of space* at different times, there is *motion*, though we cannot see the progression." A similar deduction convinced them of the motion or *some equivalent* of motion, in *electricity*.

See *Ibid.*, " Correlation of Physical Forces," by W. R. Grove; title, Motion, p. 26.

When, therefore, Philipp Reis conceived the idea of

controlling a current of electricity by the vibrations of a membrane actuated by the air vibrations of sounds, the conception involved as a necessary corrollary, that the vibrations in the electric current would be—and if the sound was reproduced *must* be—similar in their variance to the changing motion in the air vibrations.

Another more particular, but still fundamental doctrine of philosophy at the time was, that where motion in one sphere of action or phase of existence (such as the mechanical motion of matter), produced a definite result, which result it is desired to continue through another mode of action, or other condition of existence (as for instance, electricity); that result can be attained only by a practical preservation, at the points of junction of the two forces, of all the conditions and characteristics of movement which mark the originating force. This general knowledge lay at the basis of Bourseul's first conception of a telephone acting by the united and correlated elements of air and electricity. Specifically, it was that the acoustical effect of sound upon the sense of hearing, when produced through intervening media, must preserve throughout those media an action strictly equivalent to the action resulting directly from the sound itself. This we shall find was well known as a general philosophical principle by Philipp Reis; and in his writings, now to be referred to, we shall find evidence of his comprehension that in the mechanical and electrical operations to be employed, this principle must be respected and availed of. He says:

"The extraordinary results in the field of telegraphy have probably often raised the question, If it might not be possible to transmit musical tones* themselves (Tonsprache) to a distance?" (Reis and Bourseul publications, p. 11, *et seq.*; O., p. 1863, *et seq*).

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* See Tonsprache translated in the record of the Spencer case, p. 182, as "Speech." See also the testimony of Mr. Bjerregaard, (Mol. R., p. 673. O. p. 1070.)

"A reproduction of tones (Tonen) at certain distances by means "of a galvanic current has probably been thought of. * * *

"To a person having only a superficial knowledge of physics, "the problem presents far less difficulties, simply because the most "of them are unperceived. About nine years ago (1851) I also "(having extraordinary enthusiasm for what was new, and an in- "sufficient knowledge of physics) had the boldness to attempt the "solution. * * *

"Later, after further study and experience, I came to see that "my first experiment had been a very rough and by no means con- "clusive one. * * *

"Youthful impressions, however, are strong, and therefore not "easily effaced. I could not get rid of the thought, * * * and "thus half unwillingly this project of my youth was reviewed in "hours of leisure. The difficulties and the means for overcoming "them were weighed, but for the present at least no experiment "was made.

"How indeed could a single instrument reproduce the combined "effect of all the organs occupied in human speech? This was "always the cardinal question; finally I got the notion of putting "the question in another way:

"*How is* OUR EAR *affected by the totality of vibrations produced by "the organs of speech all simultaneously active?* or more generally—

"How are we affected by the vibrations of several simultaneously "sounding bodies?"

In this question he had resolved the chief difficulty which lay in the way of the later achievements. When he realized that the successful transmission of speech was to be accomplished only by imitating the *hearing*, rather than the *speaking* functions of man, he had accomplished much. His reasoning upon the functions of the ear go far also to refute the notion that he intended his apparatus—which was to simulate the ear—should, unlike the organs of hearing, be broken and disrupted in its operation. Not knowing at the time what precise influence might be due to the exterior parts of the ear in the complete act of receiving the sensation of sound, his first instrument was carved in the form of the auricle, or outer ear, and its inner mechanism imitated the articulations, interaction and unbroken connection of the little bones of the ear, through which mechanical mo-

tion is communicated from the *membrana tympani* to the fluid of the interior ear; through it to the little nerves which lead up to the greater auditory nerve; and to the ultimate connections with that portion of the brain in which such sensations are perceived. The form of this first attempt at a telephone will be found in Appendix No. 1 (see testimony of Prof. Van der Weyde, Mol. R., p. 288).

In respect to the *sensation* of tone, the term "loudness" had been given, in the literature of science, to describe a certain comparative effect. To another sensation the term "pitch" had been given. To another sensation, which distinguished the source of the sound, the term "quality" had been given. To the action of the air particle in producing the sensation of loudness, the term "amplitude" had been given—being exactly and precisely descriptive of what was requisite to be done to produce this sensation. To the sensation of pitch the term "rate" had been given. To the sensation of quality the term "form" is *now* given, but at that time it was not in much use. The term "form," as indicating that characteristic of a vibration which produces the effect of quality, appears first, long after the existence of quality and the facts or acts which constitute it were known.

Some term was required to express what was then known of quality, and the term "amplitude" appears to have been in somewhat common use, awaiting that development of a more accurate, discriminating terminology which always grows up with increased experience of the thing itself. Having a knowledge of these laws, but being restricted by the terminology in common use, Philipp Reis proceeds to describe what "must happen in order that we may perceive a single tone" (Reis and Bourseul Publications, p. 12); **O.**, p. 1864.

"Without our ear," as he informs us, "any tone is nothing else "than a recurrent condensation and rarefaction of some body re-

"peated at least seven or eight times in a second. If this occurs "in the same medium in which we are, the membrane of the ear is "at each condensation forced toward the middle ear, to be moved "at the subsequent rarefaction in the opposite direction. These "vibrations produce a synchronous raising and falling of the ham- "mer upon the anvil * * * and a similar number of tremors in "the fluid of the cochlea in which the filaments of the auditory "nerve are distributed. The greater the condensation of the sound- "conducting medium at any given moment, the greater is the "amplitude of the vibration of the membrane and hammer, and "consequently the more powerful the blow upon the anvil, and the "vibration of the nerves by means of the fluid.

"The office of our organ of hearing is, therefore, to transmit "*with certainty* up to the auditory nerve, every condensation and "rarefaction occurring in the surrounding medium, but the office of "the auditory nerve is to bring to our consciousness *the vibrations* "*of matter* which have occurred in a given time, both as regards "number and amplitude. Here for the first time certain *combina-* "*tions* receive a name; here certain vibrations are tones or "noises."

In speaking of "certain combinations" the idea of *form* of motion—which was known to result from the making of sounds in *combination*—must be considered as expressed in the term "amplitude." As it was known to all, that wave length did not produce quality, —when the term amplitude is used in connection not alone with the loudness of sounds, but with the *combination* of sounds, it is the same as to say, "the quality" of the combined sound. *It is manifest that all changes now signified by the present term* "form" *are intended to be included in the use of the term* "amplitude."*

"Before this time I had perfectly satisfied myself that the true and only method for the telegraphic transmission of vocal sounds involved as its fundamental element an apparatus which should transmit amplitude or intensity as well as pitch—for 'quality,' or timbre, or articulation, were ultimately *resolvable into these two characteristics* of vibration, &c., to be transmitted." (Deposition of Park Benjamin, Mol. R., p. 2158, quoting from Prof. Bell's affidavit in complainant's moving papers, Drawbaugh Ca.)

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* Prof. Bell's affidavit:

Prof. Cross' Deposition, New Jersey McDonough Case:

"Cross-Int. 111. Now, is it not a fact that the quality of all sounds whatsoever, whether noises or musical sounds, articulate sounds or inarticulate, is dependent upon the intensity and pitch of the various partial tones which respectively compose them? Or, in other words, upon the amplitude and rate of the air vibrations that produce such respective partial tones?

"Ans. It is. I have pointed out in my previous answers certain facts as to the so-called non-musical elements of quality, merely because I have sometimes known erroneous conceptions to be formed from overlooking them." (McDonough Rec., p. 162).

"Cross-Int. 432. * * *

"Ans. The quality of a sound depends upon the number, oudness, and relative pitch of the different partial tones. If the pitch and loudness of *each partial tone* can be accurately reproduced, the quality of the original sound can be reproduced." (McDonough Rec., p. 240).

"Cross-Int. 214. What do you understand him (Reis) to mean by the statement, 'Our ear can, under no circumstances, appreciate more than can be represented by these curves'?

"Ans. Reis knew that all the characteristics of sound are due to differences in the condensations and rarefactions of the air conveying the sound waves, and, since these differences can all be represented graphically, he saw and stated, as in your quotation, that it was possible thus to represent all of the variations which affected the ear." (*Ibid*, p. 186.)

"Cross-Int. 217. The passage which I quoted in Cross-Int. 213 follows immediately after the diagram to which I have referred. The language preceding the diagram is as follows, the italics being mine:

"The office of the auditory nerve is to bring to our consciousness the vibrations of matter which have occurred in a given time, *both as regards number and amplitude*. Here, for the first time, certain combinations receive a name; here, certain vibrations are *tones* or *noises*.

"What our auditory nerve perceives, is then, simply the effect of a force coming within the range of consciousness, and this force can be represented *both as to duration and magnitude* graphically by a curve.

"Let *ab* represent any given time, and the curve above the line condensation (+), the curve below the line rarefaction (—), then any ordinate raised from the end of any abscissa will represent the degree of condensation, at the time represented by its base, in consequence of which the drum of the ear vibrates." (*Ibid*, p. 187.)

"Then follows the diagram referred to, which is immediately succeeded by the words previously quoted, as follows: "Our ear

can, under no circumstances, appreciate more than can be represented by these curves, and this, indeed, is entirely sufficient to give us a clear perception of any tone, or any combination of tones.

" Taking this passage as a whole, do you not think that it was Reis' idea *that all those air vibrations which* produce the sensation of sound are *resolvable ultimately into the two elements* or characteristics of number or rate and amplitude or force; and that these two characteristics of the air vibrations could be represented graphically by curves, and that the human ear is capable under no circumstances of appreciating more than these two characteristics of sound vibrations?"

" Ans. As I have said already, I doubt whether Reis distinctly formulated the matter to himself in this manner; but, perhaps, I am led to this view more by what he does not say than by what he does say, as well as by the state of acoustics at that time. Still, I think that considering simply what Reis says in those portions of his lecture which you quote, the view taken in your question is a fair one.

" Cross-Int. 218. In fact, the curve in the first diagram of Reis' lecture represents only the two characteristics of sound—pitch and loudness?

" Ans. On the contrary, *it represents quality as well*, though Reis makes no allusion to this.

" Cross-Int. 220. Referring now to this first diagram of Reis' lecture, what element in it represents loudness?

" Ans. The maximum ordinate.

" Cross-Int. 221. And what represents pitch?

" Ans. The distance between the two successive crests of the curve, or the distance from *a* to the second point to the right at which the sinuous line intersects the straight line *a b*.

" Cross-Int. 222. And what you have called ' quality ' is represented by what in that curve?

" Ans. By the form of the curve; that is, by the sinuous line itself as a whole.

" Cross-Int. 224. Does not what you denominate ' the form of the curve ' depend upon the *amplitude* of the vibration at each successive instant of the entire time occupied by the vibration which the curve represents?

" Ans. The form of the particular curve constructed as explained by Reis shows simply the variation in density of the sound wave from point to point along its length. The mode in which the density varies, of course, depends upon the way in which the particle *varies its speed from instant to instant*, and hence in one sense depends upon the variation in distance, from instant to instant, of the vibrating air particle from its position of rest which I understood to be the sense in which you use the term ' amplitude.' Technically, however, the term ' amplitude ' is applied only to denote the extreme length of the path of the vibrating particle."

That Reis is dealing primarily with the notion of form in the movement of the air particle or the resulting quality or *timbre* in the sensation produced on the air, is evident from a consideration of the context. He says:

"What our auditory nerve perceives is, then, simply the effect "of a force coming within the range of consciousness, and this "force can be represented both as to duration and magnitude "graphically by a curve."

Having then drawn a curve in which what appears above the line represents condensation, and what appears below the line, rarefaction, he adds:

"Our ear can, *under no circumstances*, appreciate *more* than "can be represented by these curves, and this, indeed, is entirely "sufficient to give us a clear perception of any tone (Ton) or any "*combination of tones.*"

"If several tones are produced at the same time, the conducting "medium is subjected to the influence of several simultaneous "forces, and the two following laws will hold good. If the forces "act all in the same direction, the amplitude is proportional to the "sum of the forces; if the forces act *in opposite directions*, the "*amplitudes* are proportional to the difference of the opposing "forces" (Reis & Bourseul Publications, pp. 13-14). **O.** pp. 1865-6.

The circumstances—and the only conceivable circumstances—under which the forces attending speech act upon an air particle in opposite directions, is when a form is by some of the tones impressed upon the motion, which retards, accelerates, or otherwise modifies the motion which the fundamental tone seeks to impress. Thus, in a spoken word or sentence, each open or vowel sound will have a fundamental tone, which, if left to itself, would impose upon the air particle a definite rate and amplitude of motion. The overtones of this fundamental, consisting of a great variety, caused or influenced by the mouth cavities, will have the effect to impose upon the tendency imparted by the fundamental, new and sometimes opposing motions. That is what is meant

by " several simultaneous forces acting " in *opposite directions;* in which case " the *amplitudes are proportional* to the difference of the opposing forces." It is manifest that this does not result in compromising what would otherwise be the extreme length of the wave, and fixing for it a less length—as merchants accept fifty cents on the dollar when they cannot collect par. The amplitude of whatever tone in the combination is loudest must necessarily be retained, or the sense of hearing would perceive some different degree of loudness. The state or condition of things in which " the amplitudes are proportional," is one in which the amplitude, that is, the whole journey, has been interrupted and varied by a variety of shorter excursions, backward or forward (requisite for the sensation of quality), but without increasing the entire time for the entire journey (requisite to give the sensation of pitch) or diminishing the length (requisite for the sensation of loudness). If Reis were writing at the present day, he would, to express the same idea, probably not say " amplitudes," but " amplitude *and* form."

When we come to consider the curves shown by Reis to illustrate his meaning (p. 36), we perceive that he is discussing forms of the resultant vibrations and their total effect; or, as he calls it, " their totality of vibrations " upon the ear. Speaking of the combination curve determined mathematically from a summation of the curves of the three simple tones, he says, " this represents *exactly what our ear perceives* of the three simultaneous tones."

Summing up all, Reis adds :

" As soon, then, as it is possible to produce, anywhere ***and in*** " ***any manner***, vibrations whose curves shall be the same as those " of any given tone or combination of tones, we shall receive the " same impression as that tone or combination of tones would have " produced on us " (Reis and Bourseul Publications, p. 14; **O.**, p. 1866).

The words "and in *any* manner" are to be considered with reference to the subject of the lecture as expressed in the title; and to the extension of his remarks in the very next sentence to an *electrical instrument;* by which, in the number of "manners," is to be included the "*electrical* manner." The apparatus over which the operation is to take place and throughout the extent of which the "*above principles as a foundation*" are applicable, is a line wire charged with electricity from a battery, connected with the transmitter and receiver shown.

In front of the transmitting member of this apparatus, "tones or *combinations* of tones" are to be produced. With what may be taken as an introductory suggestion concerning the use of the thing, the inventor proceeds to state what has been persistently claimed to be a responsible *direction* or *requirement*—to disregard which is to be in danger of the pains and penalties resulting from an infringement of Mr. Bell's patent. Although the simple existence of such an instrument for such a purpose implies a paramount direction that in speaking to the transmitter we must do so reasonably, and in whatever manner is proven by experience the best, to make the transmitter transmit and enable the receiver to receive; still the complainants insist that we shall speak to it in such a way as will (according to their evidence) *prevent it from performing the function for which it was created.* They say we *must* speak so loudly, as to compel the contact points in the transmitter to separate sufficiently to break the current; although that will always (they say) prevent speech. This demand is justified by them, because the inventor (in a manifestly speculative way—as we insist), says:

"At the first condensation the hammer-like wire *d* is pushed "back; at the rarefaction it *cannot* follow the retreating mem- "brane, and the current traversing the strips remains broken, un- "til the membrane forced by a new condensation again presses

" the strip against *d*. In this way each sound wave causes a break-
" ing and closing of the current" (Reis and Bourseul Publications, p. 16; **O.**, p. 1871).

It is to be observed, *first*, that this is not a direction to *speak so that* the hammer-like wire *cannot* follow the retreating membrane—*in order* to break the current. It is apparently an expression of the inventor's judgment as to what in fact happens when speech is delivered in a reasonable manner, with the wish to make it heard. We are not told that he applied any tests to arrive at this opinion; and it is evident that he was expressing an inference as to a part of the subject which he did not intend to treat specifically and which it is even now, very difficult to be sure about. The only real direction is to *speak to* the transmitter, and *listen* at the receiver. If any further direction is to be implied, it is to speak in such a way as experience and good judgment may show is most favorable to insure success in the transmission.

It is to be observed, *secondly*, that Reis is describing the form of instrument commonly known as the "Bored block," (Reis and Bourseul Publications, p. 15; **O.**, p. 1870), which was laid upon its side when used, so that gravity produced little or no effect as an adjuster of relations between the so-called hammer-like piece and the strip.

Moreover, it is of no practical or legal consequence that Reis was mistaken in his *theory* of the operation of his apparatus. It is sufficient that he gave such description thereof as would enable one skilled in the art to accomplish the result pointed out—that of transmitting speech.

Treadwell vs. Parrott, 3 Fish. P. C., 124.
Hamilton vs. Ives, 6 Fish. P. C., 244 (253), S. C., 92 U. S., 426.

The principles of Reis' invention are to be deduced from all writings *and instruments*, founded thereon

duly published. The gravity instrument, and the Reis-Legat instrument, in which a spring and screw are provided to keep the contact points in contact and *prevent any injurious break*, are those most essential to be considered.*

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*The general principle of Reis' discovery will be found well stated by Prof. Brackett, Prof. Young, Mr. Van der Weyde and others. An illustrative quotation from the evidence of Prof. Henry Morton will suffice at this place:

"71 x-Int. Now, you have volunteered to swear that Reis taught us all we know of the operation of the telephone, since which time you have admitted that we know that the strength of the current varies during the transmission of speech, and that the variation bears some relation to the variation in the vibrations of the air producing the speech. Will you now point out to the Court where Reis describes these two facts as incident to the transmission of speech or as the means whereby speech could be transmitted?

"A. In the first place, I have not asserted that Reis taught us all that we know about the action of the telephone. What I did assert was that Reis taught us [involving, of course, what we knew already as supplemented by his instruction], that to transmit speech, as well as musical sounds, all that was necessary was to reproduce at the receiving station air waves substantially similar to those developed at the transmitting station. And, moreover, not only did he tell us that this theoretically could be done, but he demonstrated by actually doing it that it was done. I also stated that Reis did not attempt to explain the conditions of the electric current in the wire. As to the fact, which I not only admit, but freely state, that the electrical condition of the wire is brought about by the air motion and must of necessity have some relation to it, I do not think that it was necessary for Reis or anybody else to make such a statement as that. When he told us what he did, and when he had shown us what he did, this followed as a matter of necessary deduction which required no invention, discovery or anything else to develop. It was simply the statement that causes and effects must have some relation and mutual dependence. In other words Reis told us: If you produce a sound undulation at one end of a given apparatus, you will get a similar sound undulation at the other end, the influence being transmitted by an electric current. From this, as I say, it logically follows that the electric current which serves for this transmission must be modified by the sound waves at the one end, and must have its strength, power and the like, by whatever name you call it, changed in relation to the motion which causes modifi-

Having considered what Reis *said*, we may now turn to what he *did*.

SIXTH.

"With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the sounds of various instruments, and even to a certain degree the human voice."

Reis and Bourseul Publications, p. 15; O., p. 1870.

"In the defendant's instrument the transmission of speech is effected solely by the varying pressure of electrodes against each other, under the action of sound-waves falling upon a diaphragm, *in the manner pointed out in the Bell patent.*" "By virtue of the

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cations in it at the one end, and to the sound development which it causes at the other.

"72 x-Int. Then you mean to swear, do you, that the mode of transmission by maintaining an unbroken circuit between the transmitter and receiver, and by causing the strength of current on the line to vary in some ratio to the sound waves, was the obvious conclusion from Reis' description and apparatus, needing no invention to discover that mode of operation?

"A. I mean to say that anyone reading the description of Reis and constructing and using his apparatus so as to secure the results attained by Reis, would of necessity develop all that is involved in your question, that is, when he used the apparatus for the transmission of speech he would be using it without interruption of circuit and with a current unbroken and continuous, which varied in some relation to the air waves in sound. I do not say that Reis in his description in any way points out or indicates the use of a continuous current. His description seems to be confined to the employment of his apparatus for the transmission of loud musical sounds, and he is silent as to the special conditions which would be involved in the use of the apparatus for the transmission of speech.

"73 x-Int. Won't you answer the question, which is this: Did it, in your opinion, require no invention or discovery to construct the closed circuit telephone and to develop the mode of operation

movement of the transmitting diaphragm, under the action of sound waves, the diaphragm of the receiver is influenced to copy those vibrations, * * * and the only distinction which can be pointed out is that the mode of varying the strength of the current is by *varying the resistance* * * * instead of *varying the electro-motive force*. The energy which does the work is the same in each case."

Argument of Chauncey Smith, Esq., in the Molecular Case, at the Circuit, pp. 36–38.

Referring to Bell's patent, Mr. Dickerson said that it is

"a broad patent for a *new art* founded upon a *new discovery*, and that it includes and covers all telephones in which the electric current is *moulded into the form* of speech by the *power of the human voice*, whether the undulatory current, which is to be so moulded, is generated by the *magneto device* or by the *variable resistance device*."

Argument of E. N. Dickerson, Esq., in the Molecular Case, at the Circuit, p. 1.

"The undulatory current and the broken current are all old

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therein contained, in view of the fact that Reis' apparatus and Reis" description were known to the public?

"A. To produce a practically efficient closed circuit telephone did, in my opinion, involve a great many inventions and discoveries in addition to all that was given us by Reis, but it is also my opinion that among these inventions and discoveries the so-called discovery that the current in the wire must express undulations corresponding to those of the moving particles of air was neither necessary nor important. Reis showed us how to transmit speech imperfectly. Various improvements, such as the use of carbon in the transmitter and the use of a metallic diaphragm in the receiver were essential to make this transmission of speech practically available, but, in my opinion, this practical development was in no way influenced by any notions, correct or otherwise, as to the character of the current in the wire.

"74 x-Int. Then, in your opinion, if I understand you, that the construction of a closed circuit telephone, in which the strength of current, flowing constantly, is varied by the vibration of the diaphragm, did not constitute any invention, in view of the description and apparatus of Reis; is that what you mean to swear to?

"A. That is precisely it, understanding that your definition makes the broad claim only, and does not involve any of the means, such, for example, as those peculiar to the magneto-telephone." (Mol. Rec., pp. 642-644.)

things. They are not of the essence of his (Bell's) invention, but the essence of his invention is to undulate *or mould the current* into the desired form *by means of the air vibrations* whether that undulation is generated by a magneto machine, or by a battery" (*Ibid.*, *p.* 7).

"The whole thing is old in so far as *a* varying current is concerned. It was well known that the strength of current could be varied by changing the resistance of the line, or by varying the movement of the armature of *a* dynamo machine; *but it was not known that those changes could be so controlled as to agree in form with the air waves of sound; and that was the great discovery of Prof. Bell, who found it out and showed an apparatus for doing it*" (*Ibid*, p. 8.)

"The theoretical knowledge of the manner in which the one" (transmission of musical sounds) "could be done would, I think, necessarily involve the theoretical knowledge of the way in which the other" (transmission of articulate speech) "could be done. The practical realization of an instrument which could transmit the three characteristics of pitch, intensity and quality of a musical sound would not necessarily involve the practical realization of the transmission of articulate speech."

Testimony of Complainant's Expert, Prof. Cross, Mol. R., p. 129.

These pertinent quotations from the arguments and testimony of plaintiffs' counsel and witnesses in this case will be useful when considering the mechanical characteristics, physical action, and theory of the Reis telephonic instruments of 1861 to 1864; and their effect in fixing the "state of the art" when Mr. Bell's device was invented.

Should we find in these instruments the power of "moulding," etc.; and in these writings proof of a knowledge that "these changes could be so controlled" as to transmit speech (or in Mr. Dickerson's words, "to agree in 'form,'" &c.), *we shall have gained some material for judging whether the "art" of transmitting speech remained to be discovered—or only to be mechanically perfected, and published—at the date of Mr. Bell's discovery.*

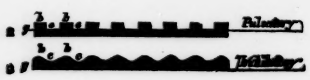
The Bell patents have, heretofore, been sustained upon a theory respecting:

First, the character and action of the current employed in the transmission of speech.

Second, an assumption that the character and action of the current employed in the Reis instruments are different.

These differences relate to spaces which can only be mathematically expressed—and to periods of time which no measuring instrument can indicate, such as the separation of $\frac{1}{1000}$ to $\frac{1}{10000}$ of an inch, or spaces of that order, and to periods of time from the $\frac{1}{10}$ to the $\frac{1}{2500}$ of a second.

It is assumed that a current undulates and does "not pulsate," the difference being something of which the mind can take no cognizance, except by graphical representations of an operation which may take place from 14 to 40,000 times in a second; and which is supposed to have a rise and fall in a manner which may be represented by a curve like that marked "pulsatory;" or in a manner to be represented by a curve like that marked "undulatory":



See Bell's London Lecture, **O.**, 2736.

Science often makes the error of generalizing from isolated facts or groups of facts whose generating cause still escapes analysis. The law, having justice for its object, cannot incur the risk of such mistakes; nor undertake to guarantee by Judicial decisions, the correctness of principles of mechanical action which are wholly founded on inference.

It takes that risk when crowning as infallible, a theory concerning things not cognizable by the senses of man.

The risk comes to have an element of grotesque absurdity when judges are asked to sustain property claims upon distinctions between pulsatory and undulatory actions taking place under circumstances which defy the microscope, and the finest instruments of precision, to find out the truth.

Mr. Harry Renwick, testifying as the Bell Company's expert in the Dowd case, was unable to find any difference in those claimed and disclaimed currents.

"Cross-Int. 18. Do you believe that there is any practical difference between pulsatory currents, so-called, and undulatory currents, so-called?

"Ans. I do not. I say this because I am not able to define where one would begin and the other would end, although there may be results produced by comparatively slow undulation which could not be produced by rapid pulsation.

"Cross-Int. 19. For the purpose of any operation described in this patent, do you believe there is any practical difference?

"Ans. As I said before, I am not able to define where one begins and the other ends, and therefore I cannot say there would be practical difference, although I can conceive that different effects might be produced by currents which change their intensity rapidly and by those which change their intensity slowly.

"Cross-Int. 20. Do you believe that any such different effects are produced for the purpose of any operation described in the patent?

"No. I don't. * * * (**O.**, 2810, 2811).

But, although the expert's fine inspection could find no difference, there was apparently a sufficient difference, in the cruder perceptions of lawyers, upon which to found a judicial judgment and support a patent. This judgment, once granted, is understood to be the justification (being admitted as evidence) in the Spencer case, for the startling announcement in that opinion that "Bell * * * is *admitted in* this case to be the original and first inventor of any mode of transmitting speech" (LOWELL, J., 8 R. 511), and in the Dolbear case, that "It was decided by the Court in the Am. Bell Tel. Co. vs. Dolbear, * * * that Bell is

the first inventor of a speaking telephone" (15 F. R., 449), and for all that spurious brood of subsequent decisions which trace their pedigree through an assumed "decision," to an assumed "admission" back to a distinction between currents which Bells' expert could not see, but the real existence of which is the very soul of his claim to discovery.

We have now to consider in detail the Reis apparatus; and first the transmitters—it being in them that the "moulding" of the current occurs which is claimed to be the essence of Bell's invention or discovery.

THE REIS INSTRUMENTS.

I.

Ear Model Form.

The first form of Reis transmitter which has been figured in any publication is the Ear Model. Appendix No. 1 shows it. An adjusting screw by which the pressure of the electrodes may be regulated is shown. The object of such a screw reveals itself. It is to control the tendency to break the metallic circuit contacts which arises from the character of the springs used and the inertia of the outer spring, which would sometimes prevent it from keeping its contact under the disrupting effect of a strong vibration.

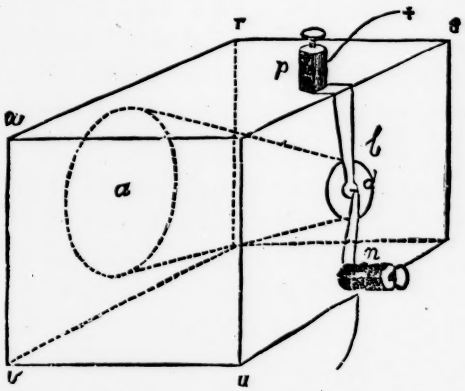
(This form was not published, and is not proved in any case. The allusion to it is for historical order and not for any legal effect.)

II.

Bored Block Form.

The second form is that shown, (Mol. R., p. 759, **O.**, p. 1870), and figured in Reis' first lecture. The exhibit produced shows a screw hole in the strip of metal extending from the binding post *n*. No screw is shown in the diagram which accompanies the published lecture.

Reis and Bourseul Publications, p. 15., **O.**, p. 1870.



In this device the current passes from one binding post through two metallic strips (one of which terminates in a platinum point, resting upon the other) to another binding post. The instrument, as a whole, rests upon its side when in use, and the outer strip is subject to the same effect of inertia. When the membrane *c* in front of the strips is spoken to, through the cone *a*, the degree of pressure between the strips is modified and the resistance to the passage of the current is varied. This may be carried in this instrument to the point of breaking the current altogether. Whether such

a break occurs will depend upon the degree of loudness in the sound, and consequent amplitude of vibration given to the membrane. Whether the interruption is whole or partial depends, therefore, upon the automatic action of the mechanism under the impact of sound waves; no provision being made for insuring a break; no direction given to speak so as to cause a break; and the object of speaking being to obtain correct transmission. The tension of the spring may be increased by bending it or making it specially thick and strong.

The transmitting portion of this device, that is, the two strips with their supports, will be shown in a plate below in connection with several other devices of this and other inventors, including Blake, in order that the essential resemblance between this original Reis transmitter and the more mechanically perfect one of Blake may be easily seen and traced.

This is called the "Bored block" transmitter. Concerning its actual capacity to transmit sounds its inventor made the statement above quoted, that with it he was able "to reproduce the tones of various instruments, and even to a certain extent the human voice."

At the same time he said:

"Now, in reference to the capabilities of the telephone, it may be stated that I was enabled to render audible to the members of a large assembly [The Physical Society at Frankfort-a-M.] melodies which were sung [not very loud] into the apparatus, in another house [three hundred feet away], with closed doors.

"Other experiments showed that the sounding wire was capable of reproducing complete chords of three tones of a piano, upon which the telephone was placed, and that it reproduced equally well the tones of other instruments, accordeon, clarionet, horn, organ pipes," etc. * * *

Also,

"Hitherto it has not been possible to reproduce the tones of human speech with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels as yet not in an equal degree. The cause of this I will attempt to explain."

Reis and Bourseul Publications, p. 17. O., p. 1872.

These statements are contained in a paper which seems to have been written out for the Physical Society after the telephone had been exhibited, and its performances shown to that Society as described.

The paper was published by the Society [see No. 9, p. 19, *Ibid.*], and it may be assumed that the fairness and truth of Reis' statements that he "was enabled to render audible to the members of a large assembly * * * melodies," etc., is beyond question.*

Didaskalia, a journal of Frankfort, May 12, 1862, reports a meeting of the Free German Institute at which Mr. Reis exhibited his telephone, adding:

"The experiments by him some months ago, in the Physical Society, were, to the astonishment of all, exceedingly plain and clear, whereas the experiment following the lecture of yesterday was less successful. This was due partly to the poor conductivity of the wires, partly to the locality" [p. 28, *Ibid.*]. **O.**, p. 1883.

The Receiver used with this transmitter is not shown in the first Reis article, but will be found figured in his circular (p. 50, *Ibid;* **O.**, p. 1907) in connection with one of the subsequent forms of transmitter. It consists of a steel needle, wound with fine insulated wire, supported upon a resonant box, the wire being connected with the telephone circuit. The current in passing around this wire causes a vibration in the molecules of the steel, the description of which will be found in Reis' paper (*Ibid.*, p. 16; **O.**, p. 1871) and need not be repeated. As a receiver, it appears, according to the evidence, to be lacking in sensitiveness, but to be more efficient in connection with some of the other transmitters than that for which it was made. The balancing of these two instruments of a new art, so

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* The similarity of experience of Reis and Bell is striking in many respects. Both sought to introduce the telephone to the public by musical concerts; and the microphone—operating as such—was introduced to the European public in the same manner (Du Moncel Telephone, p. 170-172).

that the forces of the one should be precisely adapted to the capacity of the other, may, considering the limited facilities of a German school-teacher in a little village, well be noticed in connection with the statement of Reis in his letter to Ladd (p. 44; **O.**, p. 1901).

"It would be long to relate all the fruitless attempts I made until I found out the proportions of the instrument, *and the necessary tension of the membrane*."

This simple statement should show the uncertainty if not absolute error, of the conclusion which complainants, with much beating of drums, draw from the fact that *Pisko* and some others whose papers are printed in the Reis and Bourseul publications, were unable with their Reis instruments to *get speech*.

The similar difficulties, with less degree of success, which Mr. Bell encountered are shown in various places.

HUBBARD'S CIRCULAR OF MAY, 1877.

"THE TELEPHONE."

"The proprietors of the telephone, the invention of Alexander Graham Bell, for which patents have issued by the United States and Great Britain, are now prepared to furnish telephones for the transmission of articulate speech through instruments not more than twenty miles apart. Conversation can be easily carried on after slight practice, and with the occasional repetition of a word or sentence. On first listening to the telephone, though the word is perfectly audible, the articulation seems to be indistinct; but after a few trials the ear becomes accustomed to the peculiar sound, and finds little difficulty in understanding the words.

* * * * * * * * *

"(Signed)

"GARDINER G. HUBBARD,

"Cambridge, Mass." (Mol. Rec., p. 1829).

BELL'S LONDON LECTURE.

"The results, however, were unsatisfactory and discouraging. My friend, Mr. Thomas A. Watson, who assisted me in this first

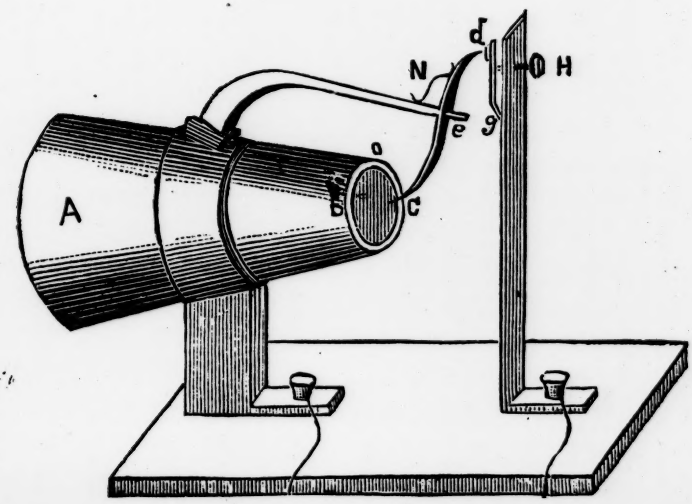
experiment, declared that he heard a faint sound proceed from the telephone at his end of the circuit, but I was unable to verify his assertion. After many experiments, attended with the same only partially successful results, I determined to reduce size and weight of the spring as much as possible" (Mol. Rec., p. 2013; O., p. 2744).

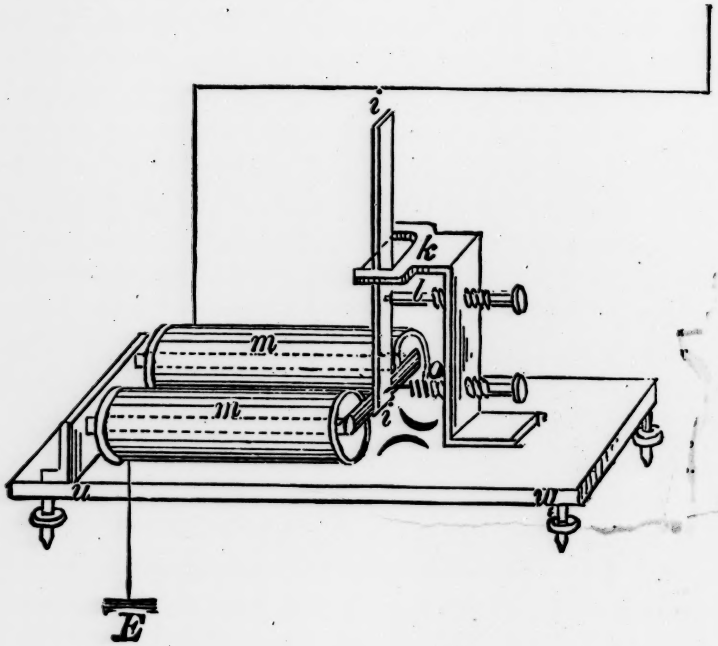
The successes finally attained were with instruments *not shown in the patent*, and—as to most of them—*not operating on the same principle.* No evidence anywhere exists to show that Fig. 7 was ever made to operate before about January, 1879.

Deposition of H. B. Renwick, p. 629, Dowd Record, Vol. 1; O., p. 3414.

III.

The Reis-Legat Transmitter.





The next form is that which is generally known as the Reis-Legat transmitter, because it is found described in the paper of V. Legat, Royal Prussian Telegraph Inspector, printed in the Journal of the German-Austrian Telegraph Association, in 1862, Reis and Bourseul Publications, (p. 29; **O.**, p. 1884).

Legat introduces this instrument without saying by whom it is made, but refers to Reis as the author of the ideas upon which it is based. He begins by saying:

"In this essay, we shall * deal with the * * * application of this current to the production of audible signals—of tones.

"The air waves * * * excite in us the sensation of sound by primarily setting the tympanum of the ear into vibratory motion; * * * and the attempt to reproduce tones therefore depends on

this, to actuate an artificial imitation of this lever apparatus by means of the vibrations of a membrane corresponding to the membrane of the ear drum, and thereby to open and close a Galvanic circuit. * * *

"Before describing the apparatus to be used, it would be proper to inquire *how our ear apprehends* the vibrations of any one particular tone, and the *combined vibrations* of *all simultaneous tones* acting upon it, *because* thereby we may *determine the operations which are to be performed* by the *transmitting* and *receiving* apparatus in the solution of the problem" (pp. 28-30, Ibid). **O.**, pp. 1883-1885.

Having thus taken, as Reis had done before, the continuity of the physiological action in the ear, as his model, he proceeds to say:

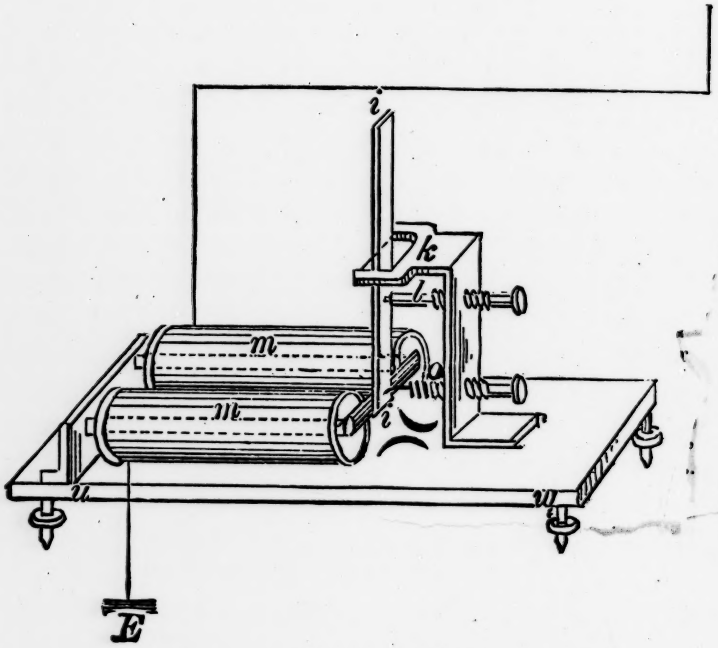
"Examining first the processes which take place in order that the human ear may apprehend any single tone, we find that each tone is the result of alternate rarefactions and condensations repeated within a fixed time. * * *

"These vibrations cause *corresponding* movements in the auditory bone, and are thereby transmitted to the auditory nerve."

Following the analogies of this model, and comparing the organs of hearing and tone sensation to a telephone circuit, we may say that the drum of the ear corresponds to the diaphragm of the telephone transmitter; that the little ossicles; the membrane against which the stirrup bone rests; the fluid in the cochlea against which that membrane is pressed by the motion of the stirrup bone; the fine nerves—called the "fibres of Corti"—which the fluid moves and presses; the auditory nerve and its connections—may together be considered the transmitter and line wire of a telephonic system; and that portion of the brain to which motion in some form is communicated; and where, by such motion, sensation is produced and sound perceived, may be regarded as the receiver of a telephone system.

Legat continues:

"The greater the *degree* of condensation * * * the greater will be the amplitude of vibration of the membrane and auditory bones. * * * Hence it is evidently the function of the auditory appara-



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Legat continues:

"The greater the *degree* of condensation * * * the greater will be the amplitude of vibration of the membrane and auditory bones. * * * Hence it is evidently the function of the auditory appara-

tus to impart *with faithfulness* to the auditory nerves *every* condensation and rarefaction which occurs in the surrounding medium * * * the function of transmitting to our consciousness both the number and amplitude of the *resulting* vibrations occurring within a given time devolves upon the auditory nerves."

* * * * * * * *

"Accordingly, that which is apprehended by the auditory nerve is the effect of a force. * * *

This force Legat represents, as did Reis, by a curve, saying :

Let the length of the line *a b* represent a definite period of time, the curves above this line the condensations (+), and the curves below this line the rarefactions (—), then every ordinate erected at the end of any abscissa will indicate at the MOMENT *of time indicated* by this abscissa *the degree of condensation* in consequence of which the membrane of the drum vibrates."

This description may without change be applied to any curve of articulate speech ; like the well-known "Brown University Curve" (Mol. R., p. 102 ; **O.**, p. 129), in which ordinates erected at the end of any abscissa would "indicate at the *moment* of time indicated by this abscissa the *degree* of condensation."

Legat adds :

"The ear *is not capable* of perceiving *more* than can be represented *in this way*, or more than can be represented by similar curves ; this is, however, sufficient to convey to our consciousness any single tone or any desired combination of tones. For if several tones are *generated simultaneously*, then the *sound-conducting medium* is influenced by *several forces acting at the same time*, and subject to mechanical laws.

* * * * * * * *

"From these principles it follows that the curves representing the condensation of a number of simultaneously generated tones may be *combined in a single curve of condensation*, which will indicate with precision *what our ear apprehends* through the reception of these simultaneously acting tones" (p. 31 ; **O.**, p. 1887).

"This * * * was necessary to demonstrate that as soon as we are able, in any place and in any manner, to reproduce vibrations, of such curves and intensities,"

That is to say, of such character or form and such loudness—

"as are equivalent to the curves and intensities of * * * any particular combination of tones, we shall have the same impressions as were produced upon us by * * * these original combinations of tones.

"The apparatus described hereafter offers the possibility of producing these vibrations in every manner desired; and *by the use of galvanic electricity* it is possible to evoke, at any distance, vibrations like those which have been so produced, * * * " (*Ibid.*, p. 32; **O.**, p. 1888).

"In consequence of the *imperfection* of the apparatus at this time, the *minor differences* of the original vibrations are distinguishable with more difficulty, that is, the vowel sounds appear more or less indistinct, inasmuch as each tone depends not merely upon the *number* of the vibrations of the medium, but also *upon its condensation and rarefaction*" (*Ibid.*, p. 35; O., p. 1892).

The words last quoted distinguish between the *number* of vibrations (which has relation to the pitch of the sound), and the condensation and rarefaction of the medium; which is the same as to say the character, degree and order of that condensation and rarefaction; which again is the same as to say, according to the *form* of such condensations and rarefactions. These words to the physicist are the equivalent of all that could be said by way of defining the terms *form* and *quality*.

As may be easily figured to the imagination, an air condensation which is occasioned by several simultaneous tones, *ex. gr.*, articulate speech—will consist of one long or complete condensation, interrupted by attempted rarefactions, renewals of the course of condensation, and varieties in the rate of speed in the main condensation. Thus condensations have their minor degrees inside of their complete degree; and for this reason air particles acted upon by the condensation of the mass have their complete amplitude for any degree of loudness, and within that, a vast variety of lesser and inferior amplitudes, which serve to represent the distinctive quality of the sound.

Legat adds:

"This also explains why chords and melodies were transmitted with *marvellous accuracy* in the practical experiments hitherto made, while single words in reading, *speaking*, etc., were less distinctly recognizable, *although even in these the inflections of the voice*, as in *interrogation*, *exclamation*, *surprise*, *calling*, etc., were clearly reproduced. There is no doubt that the subject we have been considering, before it becomes practically valuable for use, will require considerable improvement; it will especially be necessary to *perfect the mechanism of the apparatus* to be employed; * * *"

Reis and Bourseul Pub., p. 35; **O.**, p. 1892.

Returning now to the apparatus used by Legat, and which he thinks will need to be perfected, we find the principle of the first Reis instrument developed in another, which contains all the mechanical appliances (*N* and *H*) requisite to maintain the electrodes in a constant contact; or at least such contact as shall be sufficiently loose, flexible and constant, to transmit *all tones which the ear can perceive.*

We find also, for the first time, a receiver consisting of an electro-magnet, *m*, with a movable armature and sounding plate, *i*; a screw and adjusting spring, *b*, *c*, by which to hold the armature, *i*, to precisely that relation to the magnet, *m*, which will enable it, in obedience to the electrical undulations which have come to it over the wire, most effectually to reproduce the vibrations first heard at the transmitter. This receiving instrument contains every essential principle and element found in the hand telephone covered by the Bell patent of 1877, and now in universal use.
intimations or recommendations as to the dimensions of the different parts, and statement of the result of practical experiments by which certain things are shown as to the relative efficiency of different materials, etc., makes an especial statement that

"It is also desirable that the lever itself be made as light as possible, that it MAY *follow the movements of the membrane.* ANY *inaccuracy* in the operation of the lever *c d* in this respect will pro-

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Afterward he adds:

"The operation of the apparatus described is as follows:

"When at rest the galvanic circuit is closed. When the air * * * is alternately condensed and rarefied, by speaking into it (or by singing or introducing the tones of an instrument), a movement of the membrane * * * is produced, *corresponding* to such *condensation or rarefaction*. The lever *c d* FOLLOWS the movements of the membrane, and opens and closes the galvanic circuit * * * so that at each condensation of the air in the tube the circuit is opened, and at each rarefaction the circuit is closed" (*Ibid.*, p. 34; **O.**, p. 1891).

In this description, the writer, if he meant by "opening and closing," a complete severance of the electrical current which results from the use of a Morse telegraph instrument by hand, was—probably—mistaken. The mistake probably arose from two causes: *first*, an absolute correspondence with the continuity of action and motion of the air wave being assumed (in obedience to well recognized laws) to happen in the electrical current, the writer erroneously assumed that such continuity would result from what he calls opening and closing—that being the familiar method of telegraphing; *second*, Legat was expressly excluding from view any consideration of the precise manner in which the current could be put into the requisite "correspondence" of action, and, therefore, made no observation or test. He says:

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That is, as it must fairly be interpreted,

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Afterward he adds:

"The operation of the apparatus described is as follows:

"When at rest the galvanic circuit is closed. When the air * * * is alternately condensed and rarefied, by speaking into it (or by singing or introducing the tones of an instrument), a movement of the membrane * * * is produced, *corresponding* to such *condensation or rarefaction*. The lever *c d* FOLLOWS the movements of the membrane, and opens and closes the galvanic circuit * * * so that at each condensation of the air in the tube the circuit is opened, and at each rarefaction the circuit is closed" (*Ibid.*, p. 34; **O.**, p. 1891).

In this description, the writer, if he meant by "opening and closing," a complete severance of the electrical current which results from the use of a Morse telegraph instrument by hand, was—probably—mistaken. The mistake probably arose from two causes: *first*, an absolute correspondence with the continuity of action and motion of the air wave being assumed (in obedience to well recognized laws) to happen in the electrical current, the writer erroneously assumed that such continuity would result from what he calls opening and closing—that being the familiar method of telegraphing; *second*, Legat was expressly excluding from view any consideration of the precise manner in which the current could be put into the requisite "correspondence" of action, and, therefore, made no observation or test. He says:

"We have not here to consider the transmission of tones by means of the galvanic current, but only of the conveyance of generated sounds to another place, and in this way,

That is, as it must fairly be interpreted,

"in such a way that at the latter place a similar cause is produced, and a similar effect obtained" (*Ibid.*, p. 34; **O.**, p. 1891).

It is evident, therefore, that he made no tests, nor any particular observations by which to determine the truth of the assumption that the current did in fact open and close, like an ordinary telegraph circuit.

It may be repeated, as has been said before, that there was then no motive for the nice observations which have resulted from these great litigations—observations conducted at an expense, and with costly instruments of precision, quite beyond the resources of a poor school-teacher, and which have resulted in leaving it a matter of doubt, according to the testimony of Professors Young, Brackett and many others—whether there is not in every variable resistance transmitter now in use, some slight separation of contact between the electrodes, whether with or without an actual breaking of the current.

The precise significance intended in the use of these terms we must infer from the action and construction of the instrument itself; and from the object for which it was intended; and which, according to the statements of the writer and many witnesses, it did, in a considerable degree, successfully accomplish in his hands.

It is to be particularly noted in each one of the Reis instruments that in its normal condition, when at rest, the electrodes are in contact. This is specially mentioned by Legat in his description (Reis and Bourseul Publications, p. 34; **O.**, p. 1891): "When at rest the galvanic circuit is closed." Being so closed, *it will forever remain closed until some speech too loud* for transmission comes to create a strength of vibration sufficient to tear the contact open. The function of the machine, therefore, includes the capacity of being continuously opened or continuously closed, or intermittently opened and closed. The purpose of the inventor requires that it should be either opened or closed, according as the controlling forces of speech bring into play this *automatic* power to conform itself to them. The difference between this and the closed circuit referred to by Bell

in his patent is that Bell's method of connecting his circuit excludes all means for opening, or for varying the degree in which it is closed.

The adjustment screw and the tension springs of the Reis instrument may be availed of to bring the electrodes together with such pressure that they cannot be forced apart by air vibrations of any amplitude. In this respect the mechanism is identical with that of the Blake transmitter. The operative parts of the latter instrument consist of *two* springs of opposite tension, and one adjusting screw. The mechanical principle is that of an opened or closed contact according to the degree of force exerted upon the diaphragm. The Reis-Legat has also one spring and one adjusting screw, and the principle is also that of an opened or closed contact, according to the forces exerted from instant to instant, upon the membrane. When at rest—that is, when no force is being exerted upon the membrane or diaphragm—both are normally closed, and the current may be considered to be constantly flowing, with an uniform degree of resistance in each instrument. When the diaphragm is spoken to, there is an increase of pressure between the electrodes followed by a withdrawal of the electrodes to a degree of pressure less than the normal pressure. If the speech be not too loud the contact will be preserved though varied. If the instrument be spoken to too loudly, a withdrawal may ensue which will entirely separate the electrodes. Such separation will occur more easily doubtless in the Reis-Legat transmitter than in the Blake transmitter; but it will not occur in either, except by the exertion of an undue and improper degree of force.* That contact with the membrane is to be maintained is evident from the words:

"It is also desirable that the lever itself be made as light as possible, that it MAY *follow the movements of the membrane.*"

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* Testimony of Prof. Cross, quoted at p. 130.

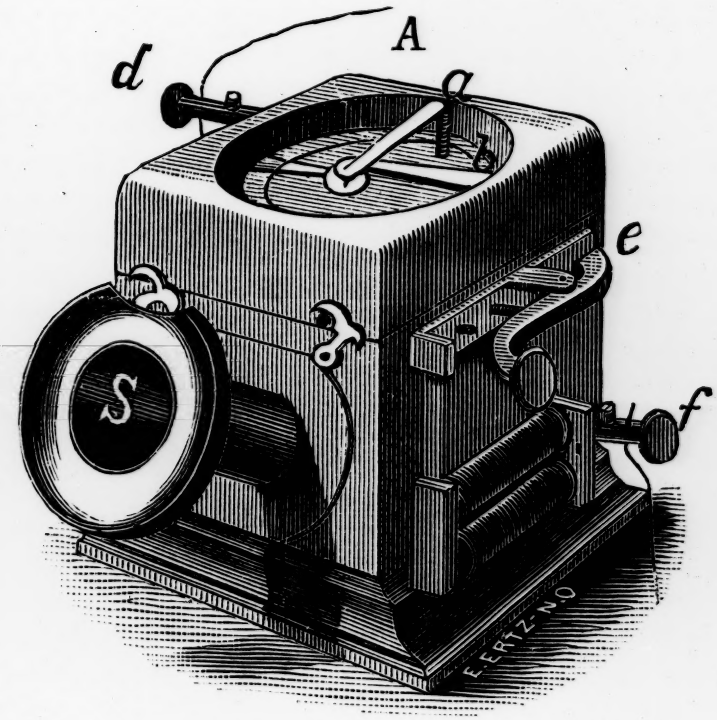
In the bored block transmitter where the tendency was still greater, Reis, in describing his experiments, and with a view doubtless of having them repeated, gives something in the nature of a direction when he says (Reis and Bourseul Publications, p. 17; **O.**, p. 1872):

"I was enabled to render audible to the members of a large assembly melodies which were sung (not very loud) into the apparatus."

The difference as to the degree of ease with which the one or the other of the instruments will be broken depends upon mechanical perfection—a point which was completely in the view of both Reis and Legat, and expressed by Legat when he says *(Ibid.*, p. 35; **O.**, p. 1892):

"It will especially be necessary to perfect the mechanism of the apparatus to be employed."

That perfection of mechanism, and that alone, is what has given to the world at this time the practical telephone—a variable resistance transmitter, united to a receiver, in principle precisely like the Reis-Legat receiver.



IV.

Gravity or Cubical Box Transmitter.

The last form of transmitter, of which we have evidence in this case (although there is evidence in scientific publications of many other forms), is what is called the gravity transmitter. This appears to have been devised by Reis *subsequently* to the writing of the paper in which he uses the words which have been so great a comfort to the expert witnesses of Mr. Bell, viz.:

"At the first condensation, the hammer-like wire *d* is pushed back; at the rarefaction it *cannot* follow the retreating membrane, and the current traversing the strips remains broken." * * *

The "gravity instrument" is so called because in the general advance of improvement, Reis had adopted the idea of resting his upper electrode directly upon the lower. The weight of the upper electrode tended to prevent a break at the point where the current passed, while the elasticity of the other supports tended to render the whole mass of the electrode and its connecting strips finely sensitive to all the more delicate wave sounds. The whole was a decided mechanical advance upon the bored block receiver, in which the rigidity of the parts and the inertia of the immovable electrode was such as to make it greatly liable to be found open when it should be closed; that is to say, greatly liable to be thrown open by the loudness of the tone, and unable to recover its contact in time for the next demand upon it by the sound waves. The only responsible description of this instrument extant is found in a letter by Reis to William Ladd, dated August 13, 1863, and a certain paper called the "Reis Circular," dated the 9th of August, 1863, and printed at pages 43 and 52, *Ibid.*

"The apparatus consists of two parts, as may be seen in the wood-cuts above, the telephone proper A, and the reproducing apparatus C. * * *

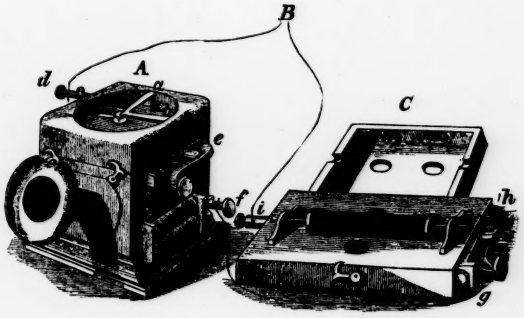
The galvanic current then goes from B to the binding post *d*, from there through the copper strip to the platina disk in the centre of the membrane, then through the foot *c* of the angle towards the binding post B, in the small hollow of which a drop of quicksilver is inserted. From here the current goes through the small telegraph apparatus *e f*, then to the key of the station C and through the coil surrounding *i* back to B.

If now sufficiently strong tones are produced before the mouthpiece, their vibrations will put in motion the membrane and the angular little hammer which lies on it; for every full vibration the circuit is once opened and again closed, and thereby are produced at station C in the core of the coil just the same number of vibra-

tions which are there perceived as tones or as combinations of tones."

"* * * By agreement between the two stations simple signals can be given by opening and closing the circuit 1, 2, 3, or 4 times, *e. g.*, one stroke—sing; two strokes—SPEAK, etc." Reis and Bourseul Publications, pp. 52, 53, **O.**, pp. 1909, 1910.

Nothing more than these words is needed to show precisely what was the error of Reis. He was under no error as to what was requisite to be done in the electric current or by the electric current. He knew, using his own language, that it is necessary to produce



"at station C in the core of the coil just the number of vibrations which are *there perceived* as tones or *as combination of tones.*"

His error was in supposing that when the circuit is opened and closed it is possible to produce "at station C" such vibrations as will be "perceived as tones, or as combinations of tones," and that his transmitter did so operate when actually transmitting speech and other sounds having form and quality. As the air particle vibration has, at the two extremities of its journey apparent points of rest, where it ceases a forward motion for a long enough time to begin a backward motion, Reis had perhaps, reasoned that his instrument, when engaged in transmitting, had also such a point of rest; that is to say, that the membrane moved forward as far as the force behind impelled it, and then for an instant

stopped, and then moved backward as far as its elasticity would carry it, and then again stopped, and again moved forward. At the end of each of these journeys he had reasoned—perhaps—that there was a point of rest, and had erroneously assumed that his automatic machine did automatically open and close the current at this point.

Whether it did or not was indifferent, since he had done nothing to bring about or to control or prevent any such opening and closing, except to call into action a law which no reasoning could change.

In these inferences we now think he was probably mistaken,—*but still it is not certain.* Had he known that he was mistaken, what could he have done, except to adjust the screws and springs more tightly in the Reis-Legat, or,—in the case of the gravity machine,—weight the upper electrode more heavily? And this would have required nothing more than the exercise of ordinary mechanical skill and judgment. He would have omitted these words from his paper, it is true, but he also would have *continued to speak to his transmitter* and *listen at his receiver, relying upon the adjustment, and automatic action of the machine under irreversible laws of nature*, for all that was to happen intermediately.

Reis's telephone was sufficiently operative, according to the statement in the Legat and Reis papers, and the proofs in the case, to have sustained a patent, and to anticipate a subsequent invention.

Pickering vs. McCullough, 104 U. S., 319.
Woodman vs. Strupson, 3 Fish, P. C., 98.

The generic principle is, that electrical energy may be controlled by the energy of sound waves, and that such electrical energy may, through the agency of an electromagnet, be re-transmuted into mechanical action of a diaphragm, and thus, into other similar sound waves.

If Reis and Legat, with Bourseul, had in 1864 applied for a U. S. patent with broad claims for the art of

transmitting vocal and other sounds telegraphically by electricity in the manner and with the apparatus shown in the Reis-Legat paper, can it be doubted that they would have obtained it? Or that Bell, coming after them, would have obtained more than a patent *limited* to his *magneto* apparatus and method?

Had they taken out such a broad patent for the discovery of the "art" of "transmitting," &c., "vocal and other sounds," can it be supposed that any errors of opinion as to the automatic or natural function of the machine would have impaired the validity of the patent?

St. Louis Stamping Co. vs. Quimby, 4 Ban. & Ard., 192.

PROBLEM.

Thus did Reis set the problem to himself and the world: HOW SHALL WE MECHANICALLY TAKE UP AND CONTROL THE AIR VIBRATIONS ACCOMPANYING ANY SOUND OR SOUNDS, AND BY THEIR OWN ENERGY CREATE ELECTRICAL ACTIONS CORRESPONDING TO THEM; AND AFTERWARDS BY THE ENERGY OF THESE ELECTRICAL ACTIONS CREATE OTHER AIR VIBRATIONS WHICH SHALL BE SO LIKE THE FIRST AS TO PRODUCE IN THE ORGAN OF HEARING THE SENSATION OF TONE WHICH WOULD HAVE BEEN PRODUCED IN IT BY THE ORIGINAL SOUND OR SOUNDS?

The problem was *mechanical.*

It was not, What *kind of electrical* action will be needed. That was known.

If one had said to him, you need electrical changes or "undulations *similar in form* to the air vibrations accompanying the sound" (Bell's 5th Claim); ample reason is furnished by his writings for believing he would have said, "Yes; *that* is what I have explained! That is what we *shall* have by the *law of nature whenever* we get *speech*, but—as Aladdin summoned

SEVENTH.

Microphones and Microphonic Action.*

We shall now consider

1. The microphonic action of the modern commercial transmitter, and its genetic relation to the Reis transmitters, especially the Reis-Legat.

2. Mechanical characteristics of Reis' instrument; and the changes in construction requisite to make them good speech transmitters—at least equally good with Bell's Fig. 7.

See for this Appendix, No. 2.

3. Proofs that Reis instruments did talk in his time; and that they will now—with proper and reasonable care—talk sufficiently well to disprove the idea that the "new art" (*Fed. Rep.*, VIII., p. 511; XV., p. 455;

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*A difference of opinion prevails among physicists regarding the real cause of the microphone action. Some, and these of the highest authority, hold that the action is due merely to the variations of resistance due to variations of pressure at the surfaces of contact of the carbons. It is difficult, however, to see how this can be the whole or even the main cause of action, for we must remember that the surfaces of the carbon in contact are continually changing in virtue of the minute electric arcs which must take place between the points of carbon which are just clear, and no more, of contact. And if the surfaces in contact are thus perpetually changing, it is hardly possible that the pressure between them could vary according to any law sufficiently regular to account for the transmission of articulate speech. It seems highly probable that the microphone is more of the nature of a very refined make-and-break, and thus analogous to the Reis transmitter, but only immensely more delicate. As a matter of fact, we know that when the microphone is used to transmit musical sounds of a definite pitch, it does act as a make-and-break, for sparks can be seen between the carbon points; and there does not seem to be any good reason for supposing that this make-and-break action ceases, and a perfectly different action comes into play when the instrument is used to transmit articulate speech.

Ferguson's Electricity, W. & R. Chambers, London and Edinburgh, 1882, p. 396.

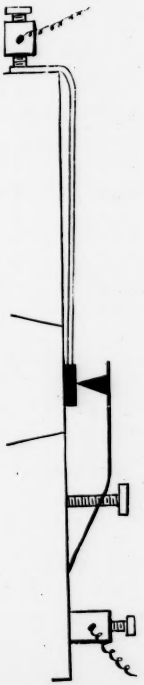
J. J., GRAY & LOWELL) of speech transmission remained to be discovered by anybody after Reis' time.

The microphone consists, physically, of two electrodes placed normally in contact, with a slight pressure, and forming part of a circuit supplied with a current from a battery.

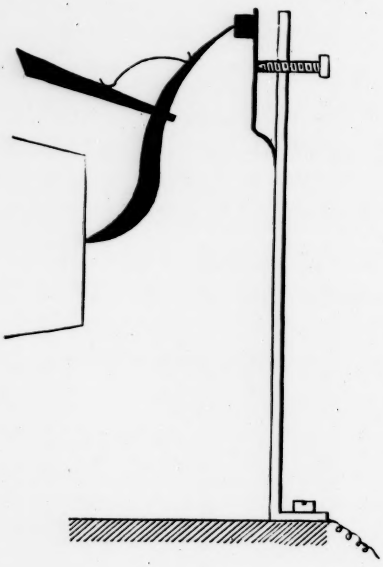
The principle of the microphone is the principle of a loose joint.

The following outline of the operative parts of the principal variable resistance transmitters may be referred to.

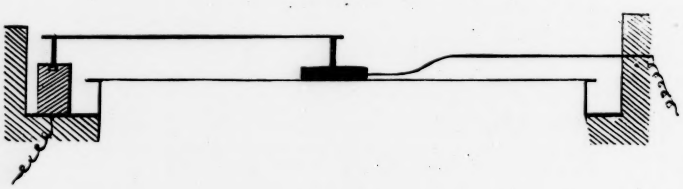
There is no attempt to represent the size of the parts correctly, and the engravings are necessarily very coarse.



No. 1 is a Reis Bored Block Transmitter, with an adjusting screw. [There is some uncertainty when this adjusting screw was added, but that it was added to some instruments is shown by the testimony of Rudolph Messel, New Jersey McDonough case] (pamphlet).

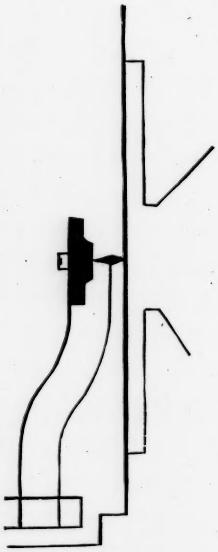


No. 2 is a Reis-Legat Transmitter.



No. 3 is the Reis Gravity or Cubical Box Transmitter, in which the operative parts are laid horizontally.

No. 4 is the Berliner Transmitter, and



No. 5 is the Blake Transmitter.

In each one of these, there is a loose contact between the electrodes.

The modern receiver, by its perfection, likewise reveals the perfection of the ancient Reis transmitter as a current moulder.* That transmitter crossed with a good receiver always produces speech.

See *infra.*

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*That the transmitter "moulds" the electrical current into a substantial conformity to the form of air vibrations is amply proven by its successful use with other receivers. Such moulding, we are told, is the essence of Mr. Bell's invention. The uncertainty and feebleness of tone of the Reis apparatus as a whole appears to have been principally due to the lack of sensitiveness in the receiver. It is as if one with a fine clear voice should deliver for re-delivery, a message to another who hears imperfectly, understands imperfectly, and speaks imperfectly. In such a case we might be dissatisfied

The history of Prof. Hughes' microphone is interesting. He was using a strained wire as conductor, and, listening at this wire, "to detect any change that might occur when the wire was spoken to, or set into transverse vibrations by being plucked aside."

Finally, by overstrain, he broke the wire, and at the instant of breaking, heard a peculiar "rush" or sound. He then sought to imitate the condition of the wire at the moment of rupture, by replacing the broken ends, pressing them together with a constant and varying force by the application of weights. His own account is:

> "It was found that if the broken ends rested upon one another with a slight pressure, of not more than one ounce to the square inch on the joints, sounds were distinctly reproduced, although the effects were very imperfect.
>
> "It was soon found that it was not at all necessary to join two wires endwise together to reproduce sound, but that any portion of an electric conductor would do so * * * provided one or more portions of the electrical conductor were separated, and only brought into contact by a slight but constant pressure."

At this moment Mr. Hughes had discovered the Reis-Legat transmitter, and the transmitter of the Reis gravity machine, which are normally "brought into contact by a slight but constant pressure," which

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with the result, but could certainly not say of the first speaker that he is an "inoperative" speaker.

We are compelled to contrast the perfected telephone of to-day with the unperfected telephone of Reis and Legat.

The improvements of Edison and others (stimulated by great rewards) upon the very instrument and idea of Reis, belong to the complainant. In truth, their existence—they being loose contact instruments—proves the virility of the stock from which they spring. And yet they stand disguised in a false livery—as elements of a "Bell" telephone apparatus. They are in fact improved Reis telephones owned by a Bell Telephone Company, which has judiciously abandoned Bell's own device and method (**O.**, 1501, 2, 3).

pressure *remains constant*, in the operation of transmitting unless *spoken to too loudly*.

Thus we see the independent origin of the microphone transmitter in two places; in Germany at the hands of Reis, and in England at the hands of Prof. Hughes. Our American investigator (Hughes) brought to the phenomenon a fullness of study, exceeding that of the German however; and pursued his investigation of what occurs just at the contact point of the electrodes to more specific, though not more exact, conclusions.

The improved microphone transmitter of commerce (such as Blake's or the defendant's), is one which varies its pressure with greater delicacy of movement than was possible to the broken wire of Hughes', or the more elaborate metal lever and contact strip of the Reis-Legat.

Besides, it employs carbon—first suggested by Edison about 1877—the action of which is not understood, but which is found most suitable for one electrode in an open and close circuit—which is to operate automatically, but which in doing so will probably be closed more than it will be opened.*

Spencer Case, p. 132, Cross-Int. 58, **O.**, p. 3957.

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*The two springs of the Blake transmitter are doubtless what make it most preferred mechanically. It has four yielding points of contact instead of two like the Reis-Legat for instance.

The defendant's transmitter has sixteen such points of contact.

This is an improvement in mechanical construction simply, and one of those which in the opinion of Judge LOWELL (Spencer Case, VIII. Fed. Rep., 458) could not have availed with a "century of Reis" to produce articulate speech.

It *has* prevailed; and has produced articulate speech by the microphonic method—a method unconceived of by Mr. Bell, except as he saw it in the devices of Reis.

Naturally enough Prof. Hughes regards himself as the inventor of microphonic action and says:

"Reis in 1860, showed how, by the movement of a diaphragm, intermittent voltaic currents could be transmitted, agreeing in exact number with the sonorous waves impinging on the diaphragm,

and thus reproducing music at a distance, by causing an electro-magnet to vibrate in unison with the diaphragm; * * *

Here Prof. Hughes distinctly states that "Reis * * * *showed how* * * * currents could be transmitted, *agreeing in exact number with the sonorous waves* * * * " (Mol, Rec., p. 214; **O.**, p. 1469).

It is by this kind of talk that Philipp Reis—dead and unfriended—has been "talked" out of his just fame.

The Court has but to refer to the Reis paper to see what is the sole justification for this form of statement—a form appropriate, if Reis had indeed demonstrated some particular fact, as facts are "demonstrated" before being placed among the received facts of science; but improper for the exact truth, that Reis was not trying to make any demonstration whether the current does or does not break. What he was trying to demonstrate or "show" was that his apparatus would transmit sounds of various kinds. What he says is:

"In this way each sound wave causes a breaking and closing of the current."

Reis and Bourseul Publications, p. 16; **O.**, p. 1871.

Assuming that "sonorous vibration" means the same thing as "sound wave" (which is much greater than air particle vibration), the expression is evidently a statement of opinion upon a matter where no opinion was really called for, and to have left which out altogether would not have impaired the sufficiency of the paper as a guide to a skilled person in making and operating the apparatus. The only persons who would have suffered in such a case would have been the experts of Bell, who, thus deprived of one, must have devised or found some other false signal by which to confuse the student of the subject. As a matter of fact it was not true, as we have seen, that his instrument operated in that way when producing speech; and Reis was wrong; though the error was without influence in his success or his failures. What "ailed" Reis was that he was born too soon; that he brought out his invention in 1861 instead of 1876; that he did this in Germany, and not in America; that he did not seek a Yankee mechanic to balance the parts of his apparatus.

The "microphone" is specifically, a certain device, consisting of a bar of carbon resting loosely its two ends into hollow cups of carbon. Concerning it Prof. Hughes said in another paper (Mol. R., p. 219, **O.** p. 1474):

"The problem which the microphone solves is this: To introduce into an electrical circuit an electrical resistance, which resistance shall vary in exact accord with sonorous vibrations, so as to produce an undulatory current of electricity from a constant source." * * *

In the discussion following Mr. Preece's lecture upon the microphone, in London, May 23d, 1878 (Mol. R., p. 249, **O.**, p. 501). Professor Bell said:

"No one can more heartily congratulate Professor Hughes upon his *great discovery* than I do. I think all those who investigate telephonic effects will realize that we have touched upon the threshold of a new science, and that we have discoveries yet in store for us.'

Mr. Bell did not think then of making the claim which his counsel have since made for him that the microphone is *only a subordinate element of Mr. Bell's own discovery of the variable resistance method of making undulations.*

At the conclusion of his explanation of the action of the new instrument, he says :

"I will not take up your time with any further remarks, but will merely again offer my congratulations to Professor Hughes upon his discovery" (Mol. R., pp. 249–251, **O.**, p. 503).

The microphone has not taken that place in telephony which was expected, and the business is carried on by instruments which are not microphones (strictly), but which operate by what is now called "microphonic action."

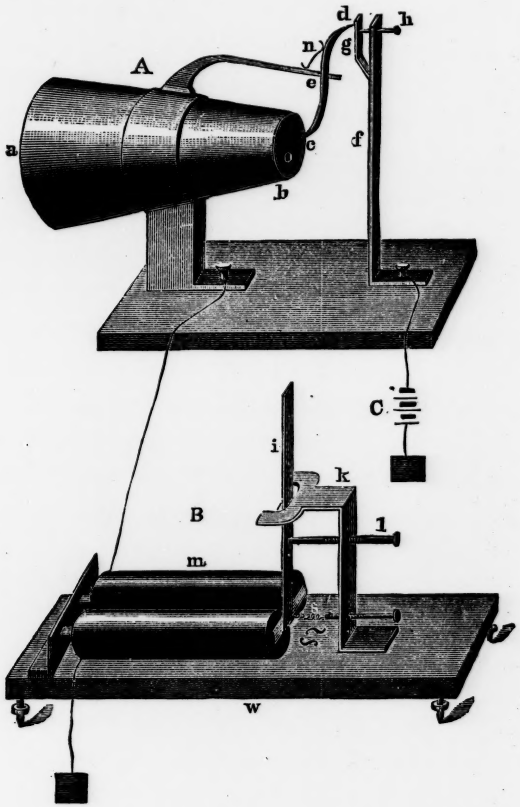
Every instrument operates by microphonic action which varies the resistance in a current by variation of pressure between electrodes; and if it does this under the influence of sound waves, and in accord with their variations, it is a telephone transmitter. Leaving out of consideration for the moment other Reis instruments, the Reis-Legat is an instrument operating by microphonic action and provided with all the regulating and adjusting means necessary to make its operation complete. It is one of the instruments which Judge Lowell said would not, by a hundred years of mere improvement in mere construction, produce a telephone.

We must now contrast Judge LOWELL'S witty but mischievous saying with the truth about the Reis-Legat receiver in order that this Court may determine whether any other than permissible changes in construction are needed to make it operate fairly well by microphonic action to transmit speech.

We have pictures of the Reis-Legat instruments which are said to be one-third of the natural size.

These are not working drawings, and while there is no reason to doubt that they are sufficiently accurate pictorial representations of instruments actually made

and used, yet it should be understood that they have not been promulgated in any such way as to bind the judgment and common sense of any operator in respect to specific sizes and dimensions of parts.



1. The tone transmitter consists of a conical tube about fifteen centimetres in length, having a front opening of about ten centimetres and a rear opening of about four centimetres.

2. The narrow end of the conical tube is covered with a collodion membrane.

3. A curved lever *c d* is suspended in such a way that one end of the lever rests on the collodion membrane and the other rests against the spring *g*, and is to be "*kept in electrical connection*" with the metallic conductor.

Reis & Bourseul Publications, pp. 32–33; **O.**, pp. 1888, 1889.

The language here used is somewhat obscure, but upon examination it is clear that no electrical connection can be maintained except through contact of the lever at *d* with the spring *g*, and therefore we must regard this as a statement that when operating as well as when at rest, the lever at its upper end *is to be kept in electrical connection with the metallic conductor by means of a closed contact with the spring g, which is a part of the conductor;* and that all other suggestions or instructions are to be understood in *subordination to this fundamental condition.*

4. The proper lengths of the respective arms of the lever *c e* and *e d* are not given, but it said that they are to be regulated by the laws of the lever.

5. The object to be attained is named. It is "in order that the least motion at *c*" (the membrane) "may operate with *greatest effect* at *d*" (contact point).

6. We are also told with the same purpose in view that, "It is also desirable that the lever itself be made as light as possible *that it may follow* the movements of the membrane," and that, "Any inaccuracy in the operation of the lever *c d* in this respect" (that is to say, any failure to follow *all* the movements of the membrane) "will produce false tones at the receiving station."

7. When in a state of rest the contact at *d g* is closed, and a delicate spring *n* maintains the lever in this position.

No other directions or limitations are expressed which should prevent any person relying on that draw-

ing (facing, page 32, **O.**, p. 1888) from modifying it in any way which he might by experiment find necessary to accomplish its professed object.

That liberty has been taken by various persons—with the result that they produce speech.

Some of these instruments were exhibited to the Commission convened by the Secretary of the Interior. It was strenuously objected for the Bell Company, that these were "false reproductions" of the Legat receiver.

It is thought useful and proper to quote the published arguments and objections upon these points; and it is believed that nothing more need be cited to maintain two material propositions;

Firstly, that with slight changes in construction the Reis-Legat instruments will successfully transmit speech;

Secondly, that when counsel for the Bell Company say that those instruments *will not*, their real meaning is that they *must not* talk, and

Thirdly, that the motive of the reason is not that the modifications requisite to make the instruments speak, are beyond the scope of the published invention, but simply, and naively, because it will be inconvenient to important established interests if they are permitted to speak.

EIGHTH.

The Reis Telephone will talk.

"*A century of Reis would never have produced a speaking telephone by mere improvement in construction.*" LOWELL, J.

Before proceeding to consider what actual changes have—by the clear admission of complainant's counsel—sufficed to make the Reis-Legat a talking telephone, it will be instructive—if not in respect to the

science of physics, at least in respect to the just value to be given to the complainant's views—to consider (1) Professor Cross' ideas about mechanical deficiencies and their effects; and (2) Mr. Bell's "improvements," by which he at last attained speech with his very imperfect and disappointing, but nevertheless, *patented* apparatus.

(1) (Cross-Q. 53, Mol. R., p. 1915):

"Ans. In an absolutely perfect apparatus there would be exact similarity between the acoustic and electrical undulations, and they would be represented by exactly similar curves.

"In proportion as this theoretical perfection is departed from the result becomes less and less satisfactory.

"An extremely slight departure from theoretical perfection impairs noticeably the operation of the instrument, and changes which would be scarcely evident to the eye, if the curves representing the vibrations were represented on any moderate scale, would probably render the instrument nearly or quite useless for the practical transmission of speech."

"The same conditions hold here that hold in an acoustic telephone."

"It is evident, however, from the effects on the ear of a listener at the receiving instrument when the Reis transmitter is spoken into in such a way as to prevent the circuit from being broken, and so to act as a microphone rather than as a circuit-breaker, that the undulations are much smaller than when the same strength of voice is used with the instrument shown in Fig. 7 of the Bell patent, No. 174, 465, or the ordinary magneto or the commercial telephone." Dol. Rec., p. 516.

See also Appendix, No, 3.

(2) Prof. Bell applied, on the 20th of January, for a patent on an instrument (which he now tells us is a speaking telephone, but) concerning which he said (Mol. R. facing 2083) on the 28th of December preceding it.

"The varying pitch of the voice could be discriminated, *but not the quality*. A sort of muttering effect was perceived at the receiver, and when a person talked very loudly at the other side."

He proceeded after obtaining his patent for that de-

vice to make improvements in it until on the 28th of February, 1881 (Interference Case, Vol. III.), he was able to testify as follows:

"Int. 39. I wish you would compare your magneto telephones which are in commercial use to-day with the magneto telephones which you used at the Centennial on June 25th, 1876, and tell me whether those of to-day do or do not practically transmit speech with greater perfection than those used at the Centennial?"

"Ans. They do transmit speech with greater perfection."

"Int. 40. Will you tell me whether the difference between them, which leads to this difference in practical results, consists in a change in the mode of operation from that described in your patent 174,465, and set forth in the report of the Centennial Judges, or whether it consists in improvements in the construction of the instruments without change in the mode of operation?"

"Ans. It *consists in improvements in the construction* of the instruments without change in the mode of operation."

Taking the proofs of the actual performance of the Reis instruments as shown by the witnesses Bohn, Hold, Schmidt, Hauser, Messel, *et al.*, (N. J. McDonough pamphlet) by whose evidence it is proven—in a way which must be satisfactory to all but those who *will not* be convinced—that words and sentences were transmitted—let us now see what changes (thought by Mr. Storrow to be *non*-permissible) have been made to insure the Reis-Legat being a fairly good *speaking telephone.*

Mr. Storrow's argument before the Department of the Interior, page 109, says (italics, &c., being ours):

"If I have a given apparatus, and weight it a little more, the same force will no longer make it break. On the other hand it is perfectly possible if you do not weight it any more, but make the force much feebler, that it will not break. Or without changing the weight or the force, you can make that diaphragm stiffer, and the same blow will not bend it enough to throw the hopping piece up and make it break. Whether it performs the breaking operation, or the contact-preserving operation, depends upon the relation between the force applied, the elasticity and the stiffness of the diaphragm, and the weight up above. Those are the factors. You can readily see that in so delicate an instrument as one to be operated by the voice a very little change in one of these factors may

change the relation, and consequently the kind of operation entirely.

Thus he says that the instrument will talk, but—*by implication—that it must not.*

Mr. Storrow, *Ibid.*, page 117 :

"This other instrument is what our opponents produced and called the same thing. There is a *spring* which they wish you to believe is the *piece g* (1). The bar *f* has two screw holes. I do not know which hole they put the screw *h* into, but I think in the lower screw-hole. There are two screw-holes here in their instrument, and I should not think it made much difference, because with that long slender *spring* all parts of it yield. There is a long slender spring with a weight and carbon on the end. Why, sir, that is just the Blake transmitter spring. It is of the same length and stiffness, both are No. 31 Brown, Sharp Guage (.009 of an inch); rather less weight at the end. Instead of taking this *g* of the Legat article, which is not *springy* (2) *at all* under the force of the voice, and which has no sensible weight at the end, they take the long slender spring and *weighted end* standing upright of the Blake transmitter. OF COURSE, IT WILL TALK. It is an infringement of the Blake patent. They claim that this instrument is the same as that of Legat, and their whole case depends upon that. That is what they laid before the District-Attorney at Memphis, and said that it would talk. *It would be a surprise if it did not.* You see now the difference in construction between their *false instrument* and the *true Legat*. They use that *watch spring* instead of this *thickish bar g* (3). As you see readily, from the angular shape of *g* in the drawing, it is not an *elastic spring* (4); it is just a piece (4) that you can *spring out* enough with the screw *h* to adjust it, while here, in their false 'reproduction,' it is a *delicate spring*. There is another difference in this false instrument;

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(1) "Upon the standard *f* is arranged a *spring g*." (Reis-Bour. Pub., p. 33).

In this way by a system of graduated mis-calling, counsel finally, as will be seen, gets to speaking of this "spring" as a thickish bar. From this to a fine indignation when the mechanic deals with the spring as a "spring," and not as a "thickish bar" we have the whole theory of the owners of Bell's patent concerning the Reis anticipation. It *must* not anticipate, and, therefore, *does* not.

(2) The small piece at *d*, drawn to scale, would have a very appreciable weight.

(3) There is nothing to show that *g* is a "thickish bar." If it were not a spring, there would be no use for the screw *h*, as the spring *n* would be amply sufficient to hold the lever against a rigid piece. But it is by the balancing of the two springs *g* and *n* that the lever is made to "follow the movements of the diaphragm accurately."

(4) Legat says: "The position of *g* is regulated by the screw *h*."

there is a weight at the end as in the Blake, perhaps not quite so heavy; that is another difference between their instrument and the true Legat. Of what material is this weight? Of all the materials that have been used for the electrode or contact-piece of a microphone or *speaking telephone*, none are so good as carbon. It is not quite certain why, but it is found in point of fact that carbon is far better than any other material whatever. Blake points this out and uses it. Platinum is about the worst. For a circuit-*breaker* platinum is the best, because the spark does not melt it, and with a circuit-*breaker* there is generally a spark; but for a circuit *preserver* or microphone the carbon is far the better; so instead of platinum, which Legat had, they put on carbon (5).

"The other false Legat transmitter, which they have somewhere around here, is essentially the same, and I think does not differ at all from this, except that they have got the weight of brass instead of with carbon. It would not be so good an instrument as that with carbon, but it has the feature of the Blake which enables the instrument to preserve contact under the influence of the voice, and thereby avoid that make-and-break which Reis' own instrument shows, and which Reis *says he constructed his instrument for the purpose of performing* (6).

"THE COMMISSIONER: You said that this would not break?"

"MR. STORROW: You *can* make it break. But it has a weight, a screw and a spring. *I should think there could be no trouble in speaking to that gently enough to transmit speech without breaking* with a good receiver.

"That spring *n* in the corner, between the S lever and its long supporting arm, is described by Legat as a *very light* spring (7). That in their instrument is *very stiff* as compared with any *force the voice could exert upon it*, and, therefore, tends to *preserve contact* and prevent breaks.

"The stiffness of the spring *n* is of considerable importance as regards the question whether the instrument will break the circuit as Legat described, or preserve it as Blake intends (8). When the

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(5) Here they follow Hughes and not Bell.

(6) Reis nowhere says that he constructed his apparatus for the purpose of breaking contact. He simply states that it does break. Nobody knows that it does not do so when transmitting; though the favorite theory is that it does not.

Reis does tell what he made his instrument for, or, at least, states the principles in accordance with which he made it.

(Reis-Bour. Pub., p. 14), "As soon then," &c. "With the above principles as a foundation," &c.

(7) Legat says "delicate," not *very light*, nor "very delicate." It is to perform a certain duty, *i. e.*, maintain contact when the lever is at rest, and that alone must govern its weight, &c.

(8) The sole function of *n* is and must be to maintain contact.

apparatus of the Legat drawing is at rest, the lower end *c* of the S-shaped lever touches the stretched diaphragm. * * * If the spring *n* be *very* delicate, then there is nothing to prevent the thin collodion membrane in its outward vibration from imparting the full extent of movement to the S-shaped lever, and certainly breaking contact at *d*. That is what *Reis intended* (9) and what Legat describes. To INSURE this the bracket piece *g* must be so arranged that it will *not follow* up the retreating upper end of the S-shaped lever (10) (A)—that is to say, it must be *so stiff* that when the screw *h* has adjusted it to a certain point, it will stay there and not be moved by the action of the voice, when, now, the diaphragm, which is of thin collodion, being in the normal position of a perfectly plane surface, begins, in obedience to the rarefaction inside the cone to retreat into the cone, the lower end of the S-shaped lever *cannot follow it, because* the upper end is *stopped at d*, and the spring *n* being delicate will not bend the stiff bracket *g* back towards *h* so as to allow any such movement (11). The consequence is, that the lower end *c* does *not* follow back the retreating membrane, and that half of the vibration of the membrane has no effect on the instrument. This is of no importance for the transmission of *pitch*, because, as the bulging out half of the motion surely breaks the circuit at each vibration, that is all that *Reis intended*, and all that the transmission of pitch required. But if you wish to transmit *speech*, which depends upon

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(9) If Legat had wished to insure his instrument breaking, he would have turned his lever the other side up, and we can assume that he knew enough about levers to arrange his instrument so that it would do the work he wished it to perform. There is much talk about what Reis *intended* to do. Legat and Reis tried to explain their theory of the operation of their instruments. The only "intention" of which we have evidence is the intention to transmit all sounds upon this false premise, the superstructure of objection to Reis is based. It is a bold and consciousless assumption.

(10) If *g* was stiff it would remain where it was, and no screw *h* would be necessary. The result would have been accomplished by *n* alone. If the explanation of counsel is correct, *g* must be stiff, in order not to be knocked out of place by the *light* lever urged by the *delicate* spring *n*. The remark that the lower end of the S-shaped lever cannot *follow* the retreating membrane is a little unfortunate, because the fact that it cannot insures a closed circuit for so much longer period. It is the pressing *out* of the membrane that breaks the circuit, if it does break, and this can only be for a very small part of the time, of vibration, for it takes a larger movement at the membrane to produce even smaller separation at *d*. They must turn Legat's instrument upsidedown to support this theory.

Here again the complaint is that Legat's machine is made so as to conform to his explicit direction.

(A) It is not easy to realize the audacity of this method of reasoning in the face of Legat's words: "It is also desirable that the lever itself be made as light as possible, *that it MAY follow* the movements of the membrane *c*. *Any* inaccuracy in the operation of the lever *c d* in this respect will produce false tones at the receiving station."

(11) Legat says "the lever *c d follows* the movements of the membrane."

altering it continually and *in accordance with the variations during every part of each vibration*, you must have the movement of the diaphragm during *every instant*, impressing itself upon the electrical contact. If we are going to arrange this instrument, therefore, so that it *will* speak, we must have the parts such that the lower end of the lever at *c* will *substantially* always be *in contact* with the diaphragm, and, therefore, partake of the *whole* of its motion and every part of it, and that the upper end at *d* will not break. It will be obvious that *this can be accomplished* by altering the bracket *g* from a *bar too stiff* (12) to be moved by the voice to a watch spring, such as is used in Blake, and by making the spring *n* in the corner so stiff, or with such a strain upon it, that it will slightly overcome the springiness of the watch spring substituted for *g*, and *allow* the lower end of the S-shaped lever *to follow up* the retreating movement of the diaphragm (page 119).

"Now, that is precisely what the petitioners have done in their false Legat transmitters, and unless they had done that their apparatus would not transmit speech *under any ordinary circumstances*.

"This is the receiver, produced by them as a copy of the Legat [indicating]: the difference between this and the true one is not so great as in the case of the transmitter, but consist chiefly in this. The original receiver has a *slender spring* there at *o*; this false one has a *very* stiff one. (13)

"The difference is that with a very stiff spring you can adjust the armature very close to the magnet, put it under a greater strain by the straining screw and get a sort of tremulous vibration all over the board *i*, just as you do in the diaphragm of the modern telephone, instead of the springing vibration, and that it makes it a much better instrument for speech; you are much more liable to get speech through it, * * * So speech can only be got out of a Legat receiver [even when coupled with a Blake microphone] by using it, as Reis did *not use it*, *i. e.*, pressing it to the ear instead of placing it on a table. It is in order to do this that *the false* 3 has been made" (pp. 120–122).

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(12) Legat says nowhere that it is "too stiff to be moved by the voice."

(13) Whether the spring were heavy or light the tension would be regulated by the screw.

(13) The cut of the original shows, on the contrary, a *stiff spring*, and, if it did not, it is not to be expected that a picture-maker would be so careful in an article intended to give merely an idea of the working of the instrument, as to indicate the size of the spring. The draughtsman would draw the spring just as it happened. The only thing to consider is that the means chosen shall do the work intended for them, which was to get the right tension on the upright *i*.

Thus the case stands upon counsel's objection to improvements:

1. Bell (having a patent upon a practically useless device) objects to the use of a Reis telephone, unless it be operated so as *not* to transmit speech.

   The ground is that in his patent he has stated (a well-known fact) that certain electrical effects which he chooses to call undulations may be caused by varying the resistance in an electrical circuit; and that that may be done by certain methods (no apparatus being pointed out) not employed or capable of being *usefully* employed in any known system of telephony.

2. On being confronted with a Reis-Legat telephone (as to which his counsel are compelled to say, "*Of course it will talk*") he declares it a "false reproduction!"

   Upon looking into the specifications which are to support this charge, we find that they consist in, *first* misquoting what the Reis-Legat description requires; *secondly*, in making misleading contrasts of the misquoted words, with the exhibited mechanical improvements in the apparatus; *thirdly*, in misrepresenting Reis' *opinions* touching the function of his apparatus when transmitting speech, as being "*intentions*," "requirements," etc.; *fourthly*, in insisting that notwithstanding the paper gives directions to be followed in order that the lower lever end "MAY *follow the movements of the membrane*" (Reis & Bourseul Publications, p. 33, **O**, p. 1890), it is an offense against the patent laws so to adjust these parts as to "*allow* the lower end of *the S-shaped lever to follow up the retreating movement of* the diaphragm"; *fifthly*, to complain—uncandidly—that the whole is only "a slightly modified form of the modern speaking telephone, when the truth is that the modern tele-

phone is but a slightly modified form of Reis' apparatus.

Some of the testimony by those who have actually heard speech with Reis will be added here, along with some of the expert testimony as to when and how those instruments will so transmit.

Prof. Chas. R. Cross, Spencer Rec., p. 131–132, **O**, pp. 3956–3959, Cross-Int. 57, 58 and 59, with answers.

"x-Int. 57. Suppose a Reis transmitter of the form shown on page 10 or page 13 of said Prescott's work is spoken *into so softly* as *not to cause any actual separation* of the electrodes, will not such transmission act so as to vary the electric current so as to produce in such current an undulation *corresponding in form* to the sound spoken into such transmitter?"

"Ans. When operated in the manner described the transmitter figured on page 10 *will do this.*"

"x-Int. 58. In your opinion, will the efficiency of the Reis transmitter *vary with the kind of material* which is used for the electrodes?"

"Ans. For use as a Reis transmitter the efficiency is doubtless much influenced by the nature of the electrodes, which is well known to be the case with all circuit breakers."

"x-Int. 59. Suppose a Reis transmitter of the form shown on page 10 of said Prescott's work is spoken into so softly as not to cause any actual separation of the electrodes; will not such a transmitter produce in the electric current in the line a series of undulations corresponding to the 'quality' of the sounds spoken into such transmitter. I use the term 'quality' in the sense in which you have used it in speaking of the characteristics of sound vibrations?"

"Ans. IT WILL."

See also Prof. Cross, N. J. McDonough Cases, x-Ints. 118, 120.

It is to be noted that the witness is speaking of *his own reproductions* of Reis instruments previous to January 27th, 1881; what he may have done since then with other reproductions, or what he might do if he really desired to succeed, we do not know.

Deposition of Prof. Chas. R. Cross, Dolbear Rec.

"Have experimented with the Reis transmitter and Reis receiver and Reis-Legat. Have *imagined* that I heard and understood words and sentences but found on inquiry" (from whom we are not told) "that they were totally different from those spoken into the transmitter" (page 502).

"It is possible with the Reis transmitter to produce electrical undulations similar in form to the sound waves producing them" (p. 508).

"It is possible, by using a very powerful modern *microphone transmitter*, to produce electrical undulations so powerful that with a knitting needle *receiver* they will produce audible speech" (p. 509).

"I do not deny the possibility that in *spite of the endeavors of Reis to prevent it*, the circuit may have remained unbroken and perhaps some sounds have been transmitted by the production of electrical undulations" (p. 515).

"The only sentence which I heard correctly was, '*The sun is shining brightly.*' I also recognized the clause, '*It is half-past* ——'" (p. 528).

Prof. Cross, New Jersey McDonough Case:

"x-Int. 135. * * *

"Ans. I have been able to transmit speech intelligibly by speaking gently into a Reis transmitter in circuit with a Bell magneto receiver.

See also answers 141, 155.

"x-Int. 136. At such time, as you understood it, the Reis instrument is producing electrical undulations similar in form to the air waves?

"Ans. It is.

"x-Int. And embodies the invention of Bell's 5th claim?

"Ans. I understand that it does when so operated."

"x-Int. 189. Assume now an air wave is to impinge upon the diaphragm of the transmitter so as to increase the pressure between the electrodes; that will cause an increase in the strength of the current, will it not?

"Ans. The strength of the current will undoubtedly increase slightly."

"x-Int. 190. And proportionally to the increase of pressure?

"Ans. Approximately so, at any rate.

"x-Int. 192. By which you mean, I suppose, that there will be a substantial reproduction of the sounds, whatever they may be, that actuate the transmitter?

"Ans. The sounds will be substantially reproduced if a proper receiver, like the ordinary magneto receiver, is used."

Deposition of Prof. A. E. Dolbear, Dolbear Rec.

"With this instrument used as a transmitter, I have repeatedly heard whole sentences of spoken words, thus proving that the instrument is competent to transmit speech, whether such changes be called vibratory, undulatory or intermittent" (p. 380).

"The instrument I exhibit [now put in evidence and marked 'Defendant's Exhibit Reis Receiver No. 1'] is in all respects similar to that made by Reis, and with it I have repeatedly heard articulate speech,—not simply words, but whole sentences—and this demonstrates what was highly probable *a priori*" (p. 383).

"A Reis transmitter differing in no respect from the common Reis transmitter except in the substitution of such carbon for the mercury I have here. With this instrument it is possible to transmit speech well, which proves that during the transmission there is not a break at the platinum terminals, but that an appropriate current traverses the circuit" (p. 383).

Speaking of the Reis-Thompson receiver and the Thompson-Reis receiver, the Professor says: "It is an instrument made to sit on the table like an ordinary telegraph instrument, as if Reis expected that the sound produced by it might be loud enough to be heard by a room full of people, an acoustical condition that is unfavorable for hearing weak sounds. If, instead of mounting his receiver in this way, it be so mounted as to prevent the scattering of sounds in all directions, as it will in this, and enable them to be utilized by the ear so that the minuter actions of the receiving magnet may be better heard, the receiver is then found to perform well, and speech may be heard with such a receiver nearly as well as with the best that have yet been invented." Of the Legat receiver he says: "With such a receiver which I have had constructed for the purpose, I find that it is competent to reproduce speech in its entirety and with corresponding increase in loudness" (p. 384).

"Reis then invented an instrument for the transmission of sounds electrically, which instrument he named the telephone. He invented and constructed an apparatus suitable to be used as a transmitter and also to be used as a receiver. He declares that spoken words could be transmitted and had been by him, and I find by experiment with the same apparatus that it is competent in my hands to do the same that he said that it would do" (p. 385).

"Q. Have you taken part in the transmission and understood while listening at the receiver, without other knowledge, whole sentences by means of an apparatus of which the Exhibit Reis

Transmitter, now on the table before you, formed the transmitting member" (p. 423)?

"Ans. I have very often, both at that particular transmitter, transmitting words and sentences which I know were heard by the one at the receiver; and I have been at the receiving end when this particular instrument was at the transmitting end, and others spoke there, and I have identified their words."

"x-Int. 124. Have you, while listening at the receiver, connected with this identical transmitter heard and understood whole sentences spoken into this transmitter"? (p. 423.)

"Ans. I have heard a great number of whole sentences and feel confident of my ability to reproduce speech again with that identical instrument."

"x-Int. 125. * * * *

"Ans. I have heard such words and sentences when the receiver employed was the original Reis receiver, but always much better when magneto receiver was employed. With the latter there is never any difficulty at all."

"x-Int. 127. Do you mean, then, that with the Exhibit Reis Transmitter, now on the table, and Exhibit Reis Receiver, now on the table, coupled together with a battery and nothing else in the circuit you have by listening at such a receiver heard whole sentences which were spoken into such transmitter and transmitted electrically by means of this apparatus."

"Ans. I do."

"x-Int. 133. Will you state whether you have taken part in the transmission of whole sentences by means of an apparatus, the transmitting member of which was the same as Defendant's Exhibit Reis Transmitter, and the receiving member of which was the Reis-Legat receiver" (p. 425.)

"Ans. I have, and, in general, have found the latter to be a more efficient receiver for loudness than the knitting-needle receiver."

Experiments were made on May 31st, 1883, at Mr. Maynadier's office, at which were present representatives of the Bell Company, and the results seem not to have been very satisfactory (p. 434).

"Int. 158. As to the experiments yesterday afternoon with the Reis transmitter and the Reis receiver, state whether you in fact received any word, words, or sentences from the receiver, and how the working of the apparatus compared with its working on other occasions" (p. 439.)

"Ans. I did receive several words and sentences fairly well, but I have on several former occasions heard much better than yesterday afternoon. The room was not so quiet as the room should be when the sounds are weak and scattered as much as they necessarily are in so poor a form of receiver as the Reis knitting-needle receiver. *I have never been able to hear continuously* with such an ar-

rangement, but occasionally have heard words and short sentences when the latter were quite unexpected, and this on several occasions when testing to discover the capacity of the instrument."

Deposition of Henry C. Buck, Dolbear Rec. :

"I have frequently connected the Reis transmitter, above mentioned, in a direct circuit with one of the two receivers, and have, perhaps, invariably, been able to hear counting and single words, and occasionally whole sentences, although this *is a delicate experiment*, and requires *absolute freedom from all disturbing influences*" (p. 478).

"I have connected up this Reis transmitter with various receiving telephones in direct circuit, as, for example, a low resistance magneto-receiver. Under these conditions, if the person at the transmitter spoke in a voice of suitable strength, I was able to understand distinctly many sentences, and sometimes have been able to hear and understand nearly, if not all, that was said at the transmitter, thus showing that the Reis transmitter is capable of producing an undulatory current."

"I have also frequently connected these Reis receivers, No. 1 and No. 2 (*i. e.*, the knitting-needle and the Reis-Legat), in direct circuit with any good modern carbon transmitter, and been able to hear, while listening at the receiver, nearly, if not quite all, that was said at the transmitter, this experiment going to show that the Reis receiver is capable of receiving."

Deposition of Walter R. Eaton, Dolbear Rec. :

"Int. 5. * * *

"For the past two years or more I have made various tests with these or similar instruments at different times. I have found that after carefully arranging the conditions, I have never failed of getting from the receiver counting and familiar sentences, and oftentimes have heard sentences which I had no previous expectation would be sent to me" (p. 482).

Deposition of Henry Morton, Overland Case :

'Speaking of the three forms of transmitting instruments (*i. e.*, the cubical box transmitter described in Pisko; the brass cone-transmitter described in the Legat article, the hollow block transmitter described in the Reis article), and two forms of receiving apparatus (the knitting needle and the magnet and armature receiver in the Legat article) :

"I have experimented with all these forms. As regards the transmitters, I *have found that with each of these transmitters, if a sensitive receiver was used*, there was no difficulty in securing the transmission of words and sentences; and I *cannot say from my own experience* that there is any great difference between one and another of *these forms of transmitters* as regards their efficiency of action" (p. 125.) **O.**, pp. 744-745.

Deposition of Cyrus F. Brackett, Overland Case:

"Int. 5. Have you made any experiments with apparatus substantially the same as the Van Der Weyde Exhibits, now shown you, with reference to their capacity to transmit articulate speech? If so, please state what those experiments were, and their result."

"Ans. I have used receivers substantially like those now shown me, both the straight magnet form, using as a transmitter the ordinary Reis bored-block form, so-called in the Reis publication. Many words and sentences were spoken and clearly received, and these experiments have been repeated from time to time, and always successfully." (p. 137; **O.**, 756).

"Int. 6. Have you made any experiments with the Reis-Legat instruments, using a collodion diaphragm instead of an animal membrane, and with what result?"

"Ans. I have, with the result of being perfectly successful in transmitting and receiving articulate speech."

"11 Q. * * * *"

"Ans. On December 9th, 1883, I made trial in Washington at the Smithsonian Institution of a Reis transmitter of the 'box form,' the same being joined in a circuit with a McDonough receiver. * * * * It was easy to transmit and understand with the McDonough receiver spoken words and entire sentences, even of the most unexpected character. At a previous trial made on the same day in Washington at the laboratory of Dr. Baxter, using the same transmitter and receiver, I read certain sentences from a newspaper speaking near the Reis receiver (?) which Dr. Baxter correctly heard and reported back to me. Dr. Baxter and I then changed places, he at the transmitter and I at the receiver. I clearly and distinctly heard with good articulation many sentences respecting current facts and events." (p. 212; **O.**, 831).

"Tuesday, Dec. 18th, 1883, I also, using the Reis transmitter and Reis receiver, spoke many words and numerals to Prof. Young which were correctly heard and reported, among others, 'Little Jack Horner sat in a corner.'

"Dec. 25th, 1883, with the box transmitter and a needle receiver I heard Prof. Young say, among other things, 'Old Dan Tucker went to supper to get his Christmas pie.'

"Dec. 27, 1883, using the lever form of the Reis transmitter and

McDonough receiver I heard Prof. Young say, 'Old Grimes is dead, that good old man, we ne'er shall see him more.' 'Old Mother Hubbard's Dog fell into the well,' and many other words which I have not noted and do not remember. Also I said many words to Prof. Young which he correctly heard and reported.'

"I have used a common microphone transmitter in connection with the Reis receiver and have found that intelligible conversation can be carried on with that arrangement."

Deposition of Prof. Chas. A. Young, Overland Case

"11 Q. Will you state whether or not you have tried any of the forms of apparatus shown and described in said publication with reference to their capacity to transmit and reproduce musical tones, notes, chords, articulate sounds of speech; and if so, under what circumstances and with what result?"

"Ans. I have made such experiments in the physical laboratory at Princeton in connection with my colleague, Prof. Brackett.—On Dec. 17, 1883, we put up a Reis box transmitter in one room of the laboratory, and in another room a steel rod receiver of the construction indicated in the Reis-Pisko article, page 191 of the Spencer Record, with the exception that the electro-magnet and key, represented on the side of the transmitter and receiver, were omitted. Tunes sung by the voice were easily transmitted and well heard. Some words and sentences were also transmitted. I heard Prof. Brackett say: 'What is the price of putty?' and I also heard 'Mary had a little baby.' On the morning of the 18th of December we resumed our experiments. During the course of our experiment I heard Prof. Brackett say, 'Little Jack Horner,' etc. 'Old Dan Tucker came to town,' etc. 'To be or not to be, that is the question.' I also said to Prof. Brackett a number of nonsensical sentences that he heard and reported correctly. On Dec. 25th with a different box transmitter and a steel rod receiver we repeated our experiment with similar results. On Dec. 27th we experimented with a transmitter of the lever form referred to in the 'Reis-Legat Article' and the steel rod receiver, and we succeeded in transmitting numerals and a few other words" (p. 164; **O.**, 783-4).

"12 Q. State whether or not you have at any time, and, if so, where, and under what circumstances, used a Reis transmitter or receiver in connection with other apparatus to ascertain its or their capacity to transmit tones or articulate speech?"

"Ans. I have done so at Princeton, in connection with Prof. Brackett, on several occasions, especially on December 31, 1883, and January 1, 1884. Using the lever form of transmitter with the McDonough receiver, we obtained very satisfactory results. Whole sentences were transmitted. I said to Mr. Brackett and he correctly reported, 'Mary had a little goat, it climbed upon the

roof,' and other nonsensical sentences. On January 1 we tried the Reis bored-block transmitter and McDonough with similar and even better results. I said to Prof. Brackett, and he correctly reported, 'Mary had a little pig. It had a crooked tail and wore spectacles.' And I heard him say similar nonsense. We then put a common microphone in place of the transmitter and substituted a Reis steel rod receiver for the McDonough receiver. The apparatus talked very well indeed. The articulation was nearly as good as I have ever heard, though not very loud. I heard Prof. Brackett repeat several verses of the poem 'Chained in the market place he stood,' etc." (p. 165; **O.**, 784).

Deposition of Sylvanus P. Thompson, Overland Case.

"I first saw Reis' telephone during my Easter holiday in the year 1875, when on a visit to Manchester." Made a very crude form and transmitted with it a large number of more or less intelligible sentences (p. 524; **O.**, p. 1141).

Speaking of the Reis and Reis-Legat receiver, Prof. Thompson says: "I have heard speech delivered faithfully by both forms of receiver" (p. 528; **O.**, p. 1145).

"Reis' knitting-needle is competent to act as a telephonic receiver, both for articulate speech and for musical tones, and also for vowel sounds. I know this because I have often heard speech and vowel sounds reproduced with the utmost clearness in a receiving telephone, constructed by Philipp Reis himself in the year 1861, and which contains a knitting-needle" (p. 536; **O.**, p. 1153.

"On a balanced circuit, articulate speech is extremely well-conveyed by a Reis transmitter, even when you talk so loud that the speech is barely recognizable when the circuit is unbalanced." (p. 542; **O.**, p. 1159).

Deposition of John R. Paddock, Overland Case:

"After these experiments were completed, I continued the work by experiments with the Reis instruments. They were the cubical box transmitter and the knitting-needle receivers" (p. 666; **O.**, p. 1282).

"The transmitter was used in a variety of ways, and good articulate speech was obtained in each of these ways" (then follow on pp. 668, 669, Overland Case, many long sentences that were transmitted)." (**O.**, pp. 1284–5.)

Speaking of experiments with the Reis transmitter and receiver procured from Dr. Stein, he says that after dispensing with the adjusting screw, and using only the means furnished by the strip itself and the binding screw "With this instrument I transmitted and received with Mr. Smith a few songs, some with and some

without the words of the songs. Sentences were also transmitted of which I received single words; other sentences in which two or three consecutive words were received, and finally I succeeded with Mr. Smith in transmitting short sentences in which the whole sentence was received." (Then follows a list of sentences received, p. 672; **O.**, p. 1288).

Deposition of Eliphalet W. Smith, Overland Case:

Experimented with cubical box-transmitter and knitting-needle receiver, but could very seldom distinguish words. Changed the receiver to a Baxter, and found that the transmitter would transmit words and sentences at times so that they could be understood quite well (p. 575; **O.**, p. 1192).

Assisted Mr. Paddock using the Reis-Frankfort instruments, transmitter and receiver, *omitting the adjusting screw* and obtained the results given by him (p. 699).

Deposition of Asahel K. Eaton, Overland Case:

Used modified Reis receiver, electro-magnet with resonant box and obtained musical sounds without any trouble, and in some cases indistinct articulation of a few words or very short sentences. *This was in the fall of* 1875 (p. 681).

Afterwards used cubical box-transmitter as described by Ferguson, and the violin with a knitting-needle upon it as a receiver. From that knitting-needle receiver got very feeble results, but evidence of articulation as though some one was talking at an immense distance. With Reis transmitter and a condenser receiver like that used by Wright in Ferguson's report, got *very distinct articulation of some* words and parts of words. Afterwards perfected transmitter and *got it very distinctly*" (p. 682).

Deposition of Henry E. Waite, Overland Case:

Speaking of the Reis transmitter and needle receiver, he says:

"I have experimented; at times I got words very faintly and at other times it was just a confusion of sounds.

I replaced the platinum point with carbon, and have then been able to transmit speech very well."

At the Smithsonian Institute he talked with the Reis transmitter and Bell receiver. Afterwards coupled-up Reis cubical box transmitter with knitting-needle receiver, and was able to transmit speech perfectly. This was some time in May, 1881 (p. 562; **O.**, p. 1179).

With Legat transmitter and receiver "I was able to transmit words clearly and distinctly, and some sentences." (p. 563; **O.**, p. 1180).

Deposition of William F. Channing, Overland Case

"I have experimented with three forms of transmitters and two forms of receivers, * * * the bored-block transmitter, * * * the Reis-Legat transmitter, * * * the cubical box transmitter. One of the receivers which I have used is what is known as the Reis-Legat receiver. * * * The second receiver is known as the Reis needle receiver, * * * " (p. 146-147; **O.**, pp. 765-766).

"With a molecular transmitter and Reis-Legat receiver the following words were spoken and accurately repeated, * * * (then follows a list of sentences):

"The Reis-Legat receiver is, from my experiments, a practical instrument, talking with perfect distinctness and capable of being practically used." (p. 150; **O.**, p. 770).

"With a molecular transmitter and a knitting-needle receiver, Prof. Brackett speaking: 'Do you understand what I say?' Repeated correctly. Channing speaking: 'Do you get me now?' 'Do you get that?' Spoken with very little delay and every sentence repeated accurately, * * * the bored-block transmitter was connected with a Reis-Legat receiver, a battery being in circuit, * * * I heard (list of sentences), * * * using the cubical box transmitter of Reis and the Reis-Legat receiver * * * (list of sentences). With a Reis cubical box transmitter having a scrap of carbon on the contact point, and speaking at a distance of about eight inches from the mouth-piece, connected conversation was carried on; unexpected remarks were made and repeated back, both when the Reis-Legat electro-magnet receiver was used, and also when the Van der Weyde receivers were used. * * * I used with the Reis box transmitter Dr. Wright's silvered paper condenser with the induction coil, * * * carbon scrap being on the contact point, words and numerals were spoken and heard" (p. 151; **O.**, p. 771).

Deposition of William J. Green, Overland Case:

At the Smithsonian Institute in '81 heard the Reis transmitter talk with Bell receiver. Afterwards connected Reis receiver with Reis transmitter and heard several sentences through the Reis receiver (p. 86; **O.**, p. 705).

Deposition of Prof. Peter H. Van der Weyde, Overland Case:

"Some of the parties present, who listened, stated that they could distinguish the words of the song." (p. 43; O., p. 662).

"There were about half a dozen persons present, who said that they could understand the words of the song; among them Mr. Hatch and Mr. Finnell." (p. 52; O., p. 671).

Deposition of Benjamin P. Finnell, Overland Case:

Confirms what Van der Weyde had said about his having heard words at the experiment in 1869 (p. 109; O., p. 728).

Deposition of Dudley Blanchard, Overland Case:

"Mortar pestle pound you," were the words which I heard (p. 104; O., p. 723).

Deposition of Stephen M. Yeates, Overland Case:

Made Reis instrument talk by putting liquid between the points of the transmitter, and using his electro-magnet receiver in 1865 (p. 489; O., p. 1108).

Deposition of William Frazer, Overland Case:

Heard Reis' telephone talk at Yeates' experiment (p. 483; O., p. 1102).

Deposition of Thomas Ballard, Overland Case:

Apprentice to Mr. Yeates. Heard the Reis telephone talk in the winter of 1867-1868 (p. 477; O., p. 1096).

Deposition of A. M. Vereker, Overland Case:

Heard the Reis-Yeates telephone work in 1865 (p. 496; O., p. 1115).

Deposition of Johann Ehren, Overland Case:

Testifies that previous to 1858 he heard the Reis telephone talk (p. 503; O., p. 1122).

The following is a brief statement of the nature and contents of depositions taken in behalf of the defendants in the cause now pending in the U. S. Circuit Court for the District of New Jersey, wherein THE AMERICAN BELL TELEPHONE COMPANY are complainants, and THE NEW JERSEY TELEPHONE COMPANY *et al.* are defendants.

The stipulation under which these depositions are taken and made part of this record, and the depositions in full will be found in a separate pamphlet entitled in this case "Testimony of Rudolph Messel, *et al.*," taken on commission.

DIRECT EXAMINATION:

RUDOLPH MESSEL, thirty-eight years old; a manufacturing and scientific chemist; partner of the firm of Chapman, Messel & Co., of London; knew Phillip Reis; was a pupil from 1860 to 1863 in the Garnier Institute at Friederichsdorf, in which Reis was a master. Remembers distinctly experiments made by Reis with his telephone and the transmission of "sometimes words and sentences. Sometimes the "instrument failed to work, and words and sentences "would be imperfectly transmitted. Sometimes one or "two words of a sentence would be clearly transmitted "and occasionally the instrument would transmit no "words or sounds." Recalls the names of some of the songs which were transmitted; "Wer will unter die Soldaten;" "Ich hatte einen Comaraden" "Letzte Rose." Remembers the transmission of musical sounds of the organ and other instruments. Identifies certain of the exhibits as instruments used by Reis. Testifies that "some of the instruments in use if "the current were interrupted emitted sparks at the "receiver. This, I recollect, Mr. Reis considered highly "objectionable, and tried to avoid it."

CROSS-EXAMINATION :

Testifies : " I knew some of Reis' instruments made after 1862 had an adjusting screw; I don't know whether the screw remedied the previous defects or not." Describes a form of transmitter used by Reis, of which he annexes a drawing. " The apparatus stood " within a sort of tripod, membrane downwards, the " pin just touching the surface of a drop of mercury " contained in a small cup forming one of the terminals " of the circuit. The apparatus started off with splen- " did results, but may probably have been abandoned " on account of its great uncertainty, thus sharing the " fate of other of his earlier instruments." Witness is not aware of any published account of this experiment before 1876.

DIRECT EXAMINATION :

JOHANN PHILLIP SCHMIDT is 38 years old; paymaster in the Imperial German Navy. Was a brother-in-law of Phillip Reis and lived with him in his house from 1859 to 1864; Reis was engaged between 1859 and 1864 in experiments for the transmission of articulate speech. Witness was constantly engaged with Reis in these experiments, most of the time as speaker, Reis being the listener, and part of the time listening while Reis spoke. Was the speaker at the experiments before the Physikalische Verein, at Frankfort, and the Society of Natural History at Giessen. Remembers words and sentences and songs—among the latter the following : " Who will be a soldier "? " Morning dawn, thou lightest me to an early day "! Testifies that " Phillip Reis often used the same expressions as I, when he spoke to the transmitter and I listened at the receiver. On such occasions I clearly understood all that was spoken."

DIRECT EXAMINATION:

DR. KONRAD BOHN; 55 years old; at present Professor of Physics in the Royal School of Forestry, Asschafenburg. Knew Phillip Reis; made experiments together with Professor Buff, with certain instruments which Reis had left with Professor Buff. Remembers the transmission of the song "Schlesswig Holstein Meerumschlungen," and that it was plainly understood. Remembers hearing the complaints of the children that it was cold, and their laughing in the distance, and remembers other messages. Identifies certain of the instruments shown in the exhibits. Could not hear distinctly every single word, still from the words which were understood in most cases the sense of the sentence could be made out. Testifies that he did not possess special aptitude for easily catching imperfect transmission, and that "Prof. Buff understood a sentence which was not "plain to witness, although he had his ear on the "sounding board and was in a more favorable position "than Prof. Buff."

CROSS-EXAMINATION:

Witness testifies that he did not understand Prof. Buff through the telephone.

DIRECT EXAMINATION:

HEINRICH HOLD is 55 years old. Tanner, of Friederichsdorf. Knew Phillip Reis from 1859 to 1874. Remembers the experiments made by him in Friederichsdorf with his telephone and took part in the chief experiments. Remembers hearing musical sounds of the violin and other instruments and words spoken or sung; as, for example, "Ich hatte einen Camaraden," and many others. Identifies the exhibits. Remem-

bers hearing transmitted whole sentences, simple words and songs, more or less clearly understood.

CROSS-EXAMINATION :

Testifies that " a person standing at the end station generally understood what was said at the other end."

DIRECT-EXAMINATION :

JOHANN HAUSSER is 65 years old; until 1885 music teacher in Wasselheim ; knew Phillip Reis ; was an intimate friend ; many experiments were made by Reis in his presence ; mentions one experiment at which Professor Opel of Frankfort was present; that witness was requested to play upon the piano single tones, then two tones at the same time, then trichords ; was afterwards called to the other end, where Prof. Opel and Reis were, " when Prof. Opel " learned, to his delight, that he had written down the " tones exactly as I played them. There was an ex- " ception in the case of the tone C. Witness had struck " the C of the first added line below, while Prof. Opel " had written down the C of the 3d space of the clef."

" In these experiments there were also transmitted " words, long sentences, and whole paragraphs. We " could understand the words quite plainly. This was, " however, only possible by the listener having in his " hand a second copy of the book out of which one " was reading. Words ending in *s* or *r* were less clearly " understood." Remember well " that whole words " and sentences were spoken, and I have also heard " the same, though I cannot now remember them."

To this may be added the letter of Prof. George Quincke, now Vice-Rector of Heidelberg University, printed in the work of Sylvanus P. Thompson, entitled Philipp Reis ; and which is now read under stipulation

of counsel with the same effect as if testified to under oath.

The letter and stipulation will be found in the pamphlet above referred to.

The proofs concerning the Reis instruments may be summed up as follows:

1. Any instrument capable to transmit tones having quality is theoretically capable to transmit articulate speech.

2. The Reis instruments are capable to transmit tones having quality—to wit, musical tones of the voice, tones of various musical instruments, and chords consisting of two or more simultaneously sounded notes.

3. The Reis instruments were devised for the transmission of articulate speech.

4. The Reis instruments did transmit words and sentences in the hands of Reis and of others in his time.

5. The Reis instruments will now, using his transmitter and receiver together, "talk," though with uncertainty.

6. The Reis transmitter will transmit clearly and well when united to a good receiver, such as the McDonough, or Bell magneto-receiver.

7. The Reis apparatus entire will "talk" well, when modified in mechanical construction, without the addition of any element not already there.

8. Whenever and wherever the Reis instrument has talked, or can be made to talk, it avails of a natural method being the same which Mr. Bell has, under a name and description, the fitness of which appears as yet incapable of verification, claimed and patented.

Upon this state of facts, concerning the art of transmitting speech, before 1874, it becomes material to enquire:

NINTH.

When is an art discovered?

From an early day in the history of these litigations, any clear and masterly judicial taking hold of this question has been impossible in view of the compromising statements (in the Spencer case, 8 Fed. R., 511) that "Bell * * * *is admitted in this case* to be the original and first inventor of any mode of transmitting speech;" that "Bell discovered a new art—that of transmitting speech by electricity" *(Ibid.)*, and (in the Dolbear Case, 15 Fed. R., 449) that "it was *decided* by this Court in the American Bell Telephone Co. vs. Spencer * * * that Bell is the first inventor of a speaking telephone."

After so sweeping a disposition of this material question on the authority, in the first case, of a supposed admission, and in the second of a supposed decision in the first, there was little reason for expecting other Judges to investigate the bases of these conclusions.

In this Court, therefore, for the first time since the Spencer case, can this question be asked with an expectation of an answer on principle and facts.

When, then, is an art discovered?

To conceive that a new thing can be done; to indicate in a correct, though general way the laws of nature which must be availed of; to create suitable apparatus—although suitable only in a limited degree; to use the apparatus, and succeed in the avowed purpose—though only in a limited degree; to publish the result with sufficient specification to reveal the whole purpose, and put the world fairly upon further inquiry,

appears to take the doing of that special thing out of the category of undiscovered arts.

From that stage, in the development of that art, it would seem that invention and discovery must be deemed limited (by the state of the art) to the improvement and perfecting of old or the invention of new modes and mechanism.

This difference between the discovery of an art and the perfected practice thereof is what the Court is called on in this case to clearly distinguish.

The error below has in part consisted in the apparently unconscious assumption of a false premiss, viz., that the art of transmitting speech was undiscovered in 1876, *because* no good way of practicing had yet been worked out.

Bourseul had in 1854, by pure force of reason, predicated the capacity of electricity to transmit speech; had formulated a general expression of the law of such transmission, which is now found to include and be harmonious with all the particulars of our present state of knowledge; and had suggested an apparatus.

Reis had in 1861 pursued the law of acoustical action and effects to a fuller extent; had made an electrical machine; had challenged and solicited nature to act within the electrical and hidden part of the operation (according to her own laws whatever they might be); had received a favorable, though grudging and capricious response; and had published to the world that:

(1) "With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the tones of various instruments, and even to a certain extent the human voice" (**O.**, p. 1870); although,

(2) "It has not been possible to reproduce the tones of human speech with a distinctness sufficient for every one" (**O.**, p. 1872); that

(3) "Consonants are for the most part reproduced pretty dis-

tinctly, but the vowels as yet not in an equal degree" (O., p. 1872); and subsequently in 1864 that

(4) "Chords and melodies were transmitted with marvellous accuracy * * * while single words in reading, speaking, etc., were less distinctly recognizable, although even in these the inflections of the voice, as in interrogation, exclamation, surprise, calling, etc., were clearly reproduced" (O., p. 1892).

These publications being made, the evidence now taken, including the new foreign testimony (in the N. J. McMcDonough case, pamphlet) as to the operativeness of the apparatus, shows that it often, and in the presence of many persons, exhibited its function by transmitting words and sentences.

From this time it would seem that it was not open to Mr. Bell to discover speech transmission AS A NEW ART.

Leaving apart the consideration of any other man's work, it will appear clearly to the Court, from what was done by Varley (as it is hereinafter stated), that it was not open to any one to discover the generic art of transmitting sounds by "causing electrical undulations similar in form to the air vibrations accompanying such sound."

After examining the patent in question, it will also, we think, appear clearly, that whatever Mr. Bell may at that time have discovered in respect to speech transmission, he did not intend to, nor did he, reveal it, in that patent, to the world.

(The full discussion of this point, as well as the true history of Mr. Bell's meritorious, though greatly misrepresented and over-stated work, is reserved for a later place).

After considering what was said and done by him previous to that patent, it will, we think, be clear that he did not suppose that any apparatus then shown by him was capable to transmit articulate speech.

TENTH.

Of that which is claimed in the patent, how much is patentable invention or discovery, and how much (being novel) is non-patentable discovery of scientific facts or law of Nature?

In one of the cases on appeal (the Dolbear case) the Court says, "there can be no patent for a mere principle. The discoverer of a *natural force* or a *scientific fact* cannot have a patent for that" (p. 449), but adds (p. 453):

> "The evidence in this case clearly shows that Bell discovered that articulate sounds *could* be transmitted by undulatory vibrations of electricity, and invented the way or *process* of transmitting such sounds by means of such vibrations. If *that* art or *process* * * * is * * * the only way by which speech can be transmitted by electricity, that fact does not lessen the merit of his invention or the protection which the law will give *it*" * * * * * * * * * * * (p. 454), "the essence of his invention consists not merely in the form of apparatus which he uses, but in the *general process* or method of which that apparatus is the embodiment. * * *
>
> "Whatever name may be given to a property or manifestation of electricity in the defendant's receiver, the facts remain that they availed themselves of Bell's *discovery* that undulatory vibrations of electricity *can* intelligibly and accurately transmit articulate speech as well as of *the process* which Bell invented, and by which he reduced his discovery to practical use."

Let us analyze the claim and the facts, and then re-examine these statements, since upon the correctness of these or similar arguments the complainant hopes to convince the judgment of this Court.

The facts are that Mr. Bell, having the desire to transmit vocal and other sounds, devised an apparatus, consisting of a transmitter and receiver connected by a line wire, throughout which the phenomena of electrifica-

tion, whatever it is, is to be set up. He describes certain tangible, observable and plain things to be done. One is to make vocal or other sounds at the transmitting cone and listen at the receiving cone. If sound is heard at the latter, it will be known that it has been transmitted.

The manner of using the apparatus may be considered as constituting *a* process, to wit: "The process which Bell *invented*, and by which he reduced his discovery to practical use," *Ibid*, p. 455. This is a process of creating undulations. In its nature it is the work of human invention. The apparatus and the process of connecting it (*i. e.*, as an hermetically closed circuit including a magnet and an inductive body, etc.), were the invention of Bell.

This process (relating to the organization and mode of using the apparatus), is apparently *the* process meant by the Court in the Dolbear case, when it speaks of "a process by which a certain effect of one of the forces of nature is made useful," and also

> "The process of which he is the first inventor,"

but is not

> "*that process*" *as to which* he is "not restricted as to the particular form of mechanism by which he carries out that process."

The first two references to process evidently cover the process of *causing* undulations. The last reference is apparently to the process of *transmitting* by means of undulations which are caused.

The distinction is not arbitrary or without reason. It is essential. For the one process is the invention of man, by which he calls a law of nature into action: and the other is a scientific fact as to the way in which nature when producing certain results—by whomever, by whatever means, at whatever time, and for whatever particular purpose it has been called into action.

The 5th claim of Bell is susceptible of an easy, reasonable and—in view of the character of his specications, and the fact that the 3d and 4th claims are appropriated to secure him the two only methods of causing undulations—natural interpretation, which would limit it to a method of transmitting sounds by means of electrical undulations similar in form to the air vibrations accompanying the sounds—caused in a *magneto* telephone by magnetic induction.

Inasmuch as, according to the present conception of science, this is a description (and a good enough one for scientific purposes) of *whatever* nature does, when she consents to transmit sounds by that agency at all, *it is a claim to the exclusive service of nature in that kind of work.*

When therefore the Court in the Dolbear case say: "The evidence * * * shows that Bell discovered that articulate sounds *could* be transmitted by undulatory vibrations, etc., and invented the art or process of transmitting sounds by means of such vibrations," it is evident that the term "process" is again restricted to the way of making, connecting and using the physical apparatus; while the "discovery" is extended to a finding out that when it acts at all in such service, nature sets up a certain series and order of acts of effects which are denominated "undulatory vibrations."

When they say if "that art or process is * * * the only way by which speech can be transmitted by electricity," it seems apparent that the Court is now again speaking of *nature's* part in the business as being a process; and, when later on they say that "the essence of his invention consists not merely in the form of apparatus * * * but in the *general* process or method of which that apparatus is the embodiment," it seems that they again distribute the term "process" to *both* the invented method and the natural law.

In the brief of Messrs. Dickerson & Storrow in the Ghegan case they say:

"The individual judgment of the writer of this brief is that the claim for the apparatus, so far as this case is concerned, is as broad as the claim for the method. The gist of the invention is the new mode of operation exhibited in the *action* of the apparatus as a whole, * * * the employment of the words 'methods,' 'arts,' etc., in a broad claim, showed beyond criticism the Commissioner of Patents meant to grant a broad patent not confined to the specific form or character of mechanism shown (p. 52)."

As interpreted, therefore, by the Courts and the counsel who uphold it, the 5th claim is a claim for the electrical transmission of speech under the form of a description of how nature does it! That is, substantially in the language of Bourseul—whenever

"The syllables have been able to reproduce their vibrations throughout the intervening media."

Again they say:

"It is a patent for a method of transmitting speech by elec
"tricity, and is not confined to any particular form of apparatus.
"That method consists in producing electrical undulations sub-
"stantially similar in form to the sound waves acting on the trans-
"mitter, and by means of those sound waves themselves."

Brief in Ghegan Case, signed by Mr. Dickerson and Mr. Storrow, p. *a*.

[illegible] may be likened to a claim for raising wheat by the germination of the seed of the plant, leaving mankind free to produce wheat by all other methods!!

Or it might be likened to walking by means of the exertion of certain muscles and the placing one foot before the other successively; or to the transmission of sounds by causing to-and-fro vibrations of air particles similar, or corresponding to the movements of the vocal cords which originate the sound.

The favorite manner of describing what Mr. Bell discovered has a tendency to deflect the mind from a true bearing upon the question.

It is said in the argument and in the decision in the

Dolbear case, "Bell discovered that articulate sound *could* be transmitted by undulatory vibrations," etc., and that defendants "availed themselves of Bell's discovery that undulatory vibrations of electricity *can* intelligibly and accurately transmit articulate speech."

This manner of speaking of the discovery is as if it consisted of the finding out of some new function or capacity in, or use for, old material, customarily employed for other ends; and that in respect to whether or not it should be applied to the new use, there is some freedom of choice and of means.

In fact, what Mr. Bell has discovered—assuming now the novelty of his work—is, not that electrical undulations *can*, but that they *do*, transmit sounds by conforming themselves to the characteristics of the energy which creates the sound, and that they will do this in no other way.

This is a scientific fact.

If his theory is true and his claim to originality genuine, he had detected a secret of nature; and had found out how from the energy of motion in ordinary matter (sound) she sets up equivalent action (undulations) in the molecular, magnetic or electrical states of a conductor, and afterwards causes the force or energy to emerge from that intermediate state or form of manifestation, into its original form.

In fact he has merely reasoned on the subject, and has not, in any true sense, "discovered" anything.

In other words, Mr. Bell thinks he has discovered that the law of the persistence or correlation of forces holds good in its application to this subject.

Having so reasoned, he proceeded promptly to patent, not only a particular method and apparatus for availing of that law, but also the *right to* avail of that law by any means whatever.

Thus considered *he has been able to monopolize a natural force and patent a scientific fact.*

His apparatus and method will take no offence at any fault in the reasoning, but if properly spoken to will continue to give civil responses, even if the reasoning about its theory of action should prove untrue.

In the meantime the reasoning being patented, serves its term in restraining others from competition.

To show how clearly this case is within the reasoning used in the case of O'Reilly vs. Morse, let us drop the middle term in the 5th claim and read it as follows: "(5) The method of and apparatus for transmitting telegraphically vocal or other sounds * * * substantially as set forth (*i. e.*, the process of speaking and listening in a circuit specially arranged). Does the middle term thus left out describe anything discovered by Mr. Bell, in the sense of the patent law? If electricity undulates, Mr. Bell did not invent that action. As the claim stands, then, it is pure and simple for the use of electricity whenever and in whatever manner it transmits speech. Mr. Bell had simply coined or adopted a name that may or may not truly indicate what happens.

We are constantly to keep in mind that the method of the 5th claim is not by any fair interpretation of its terms a method for *causing* undulations. Those methods in the two only conceivable ways are covered by the 3d and 4th claims. It is for *transmitting*, &c., in one—or they say both—of the methods previously claimed.

Suppose Mr. Bell had learned or surmised that electricity, when employed in transmitting signals, gains heat or color, and is gray or blue, or red, and had said I claim not only an apparatus by which electricity can be put into a heated or colored state, but I claim electricity whenever it is hot or colored in the act of transmitting.

In what sense would this be different from claiming electricity for the work in question, since it is only in and by that condition that it performs its work.

The 5th claim, as thus interpreted, is, therefore, a claim to electricity *when undulating* under the influence of, and in conformity to the form of sound waves. Since that is the condition in which electricity was whenever it transmitted a word or a tone of quality for Reis, and is its natural condition whenever so influenced and employed—a claim to the exclusive benefit and use of that condition is a complete equivalent to a claim for an entire monopoly of electricity in sound transmission.

This claim of Mr. Bell to the beneficial use of a general law when in operation, is not to be confounded with the arbitrary and artificial method of making dots and dashes under the Morse patent,—by which arbitrary and conventional system ideas are conveyed. Morse, knowing already, and the world knowing,that the flow of a current could be interrupted, invented a certain order and length of interruption and renewals which would produce signals, the meaning of which could be fixed by agreement. This was an artificial thing; and as such signals and the way of producing them could be indefinitely varied, he was granted a patent for breaking up a current into recognized succession of interruptions and renewals. The system was wholly artificial and capable of infinite modification.

But the undulations of a current in the act of transferring the mechanical movements of air particles is a natural system. It is the system by which nature, in transmitting forms of energy from one form to another, does her work. No modification is possible. If she does her work, it is because she acts that way. If the work is not done, it is because she has not acted in that way. No convention or agreement can add to or take from the significance of her action. It is this natural effect and natural method which Mr. Bell is supposed to have *discovered*, and has been permitted—

by the construction of his patent, and not its fair terms—to hold.

It is just such a discovery as the biologist makes when looking more and more closely into the laws which are at work, he learns the process, though not the cause, of ovation and germination.

The main and general facts on those subject were long ago known to physiologists and stated—as Bourseul and Reis stated the laws which control and bring about the transmutation of energy in this business of transmitting speech by the galvanic current—but the special action is more and more "discovered" each year. Such are not patentable discoveries however; being in no sense dependent on or, derivable from, or aided by invention or investigation of man.

If Mr. Bell had claimed a mechanical combination or a combination with a method of operating it, such a claim might have been legally sustained if the facts were right; and so far as he has claimed that simply, the claim is good. Such would appear to be the true or natural interpretation of the claim, but we have to deal with a lawyer's construction which steps quite over and beyond the natural meaning, and covers not the process of Bell for calling nature into action, but the *process of nature when she has answered the call.*

Considering that the process rests upon the existence of electrical undulations which are similar in form, &c.,—it is now and without argument, at this place, submitted that no one of the famous process cases has decided anything which will justify a patent upon A PROCESS OR CONDITION, THE EXISTENCE OF WHICH IS INCAPABLE OF PROOF.

It is believed, therefore, that so much of the 5th claim as by any construction is capable to be extended to the transmission of sounds by causing undulations, should be expressly limited to what is accomplished by uttering the sound *before the transmitter of a magneto telephone,* thus creating new currents, and *thereby*

causing undulations similar in form to the uttered sound. Such an interpretation secures what Bell invented, and enough of what he "discovered" to enable him to work his invention, while not excluding other inventors from access to the universal storehouse.

ELEVENTH.

But complainants ask—If this art was discovered why did not the world, and especially Sir William Thomson and Prof. Henry know it?

The question was asked by counsel for the complainants below why, if Reis made a telephone and gave it to the world, the world had still to wait until 1876 for telephony.

The question contains in part its own answer.

It was because Reis *gave* to the world, and did not sell to an enterprising syndicate, that his invention was forgotten, except by a few, of whom Alexander Graham Bell was one (See App. 4).

Upon selfish human motives, human progress largely depends. Had Mr. Bell given his telephone to the world in 1876, it may be doubted whether the world would now have a practicable telephone system. Certainly it would not have had in obtaining that accommodation the service of the accumulated capital, intelligence and protracted efforts of lawyers, men of science and capitalists.

The plain common sense of such a matter is found in the answer of Prof. Brackett (**O.** p. 869).

The wise are not always all-wise. The couplet of Mr. Lowell

> "For down to Boston ef ye take their showin"
> "Wut they don't know ain't hardly wuth the knowin,"

is not applicable to modest men of science.

The argument which deduces non-existence of things from the fact that Prof. Henry and Sir William Thomson did not know or had forgotten them at some particular date, is one which could not have received approval from either of those eminent men.

The work of Reis was done, as we may say, in a corner. His first exhibition occurred in 1861, before a society of Frankfort, not consisting, as we understand, of scientific men. Its results were published with doubting remarks in local journals, and only very slowly crept into works upon of science. By the time it had reached recognition there, there had come to be associated with it a theory concerning the action of the instrument and its capacity,—founded on hasty and imperfect experiments with instruments which at their best are very various in their degrees of capacity, and which at all times must, in the words of Prof. Young, be handled "gingerly,"—which was misleading to all except those who, like Bell, had read Reis' own words and had understood them. Prof. Bell's citation of Reis in his American lecture shows that he knew what Reis had done, and a comparison of his language when speaking of the subject, with the language of Reis, seems to indicate more than mere coincidence. Whatever may have been the state of knowledge of Prof. Henry or Sir William Thomson, Mr. Bell was not ignorant.

Besides this we are to observe that Prof. Bell exhibited a very ingenious instrument and theory, which was novel. It was the magneto telephone in which, or by which, the energy of a voltaic current seemed to be effected by the superposition upon it of new currents generated in a magnet. This was interesting and novel, and will be found to justify the surprise of scientific men without recurrence to the larger claim that they were entirely ignorant of Reis.

Still it is probable that they were ignorant by reason

of never having known, or by having forgotten those obscure experiments.

The Court is not ignorant, however, since the facts are now proved.

There is a degree of reason in testing the date or novelty of an invention by the public state of knowledge or the knowledge of certain persons at a particular date—presumptions of a certain strength arise from what they did not know; but, like other presumptions, they disappear when the facts appear. Complainants deduce a presumption that Reis' instruments did not and cannot, transmit speech, because Thomson and Henry were surprised by Mr. Bell at the Centennial, in 1876. These gentlemen have not been asked why they were surprised? A Reis instrument was lying in the Smithsonian Institute at the time, with a latent capacity to talk, which Mr. Greene developed at the first trial. Probably Prof. Henry's attention had never been called to the words of the obscure schoolmaster Reis—or, if it had, he had interpreted them in the light of those of Pisko and others, who, seing that Reis's public musical entertainments had not been followed by any furore, and guided only by their own limited, and, perhaps, imperfect experiments, had declared, *ex cathedra*, that it was only a musical telephone. At any rate, it will not harm us to reflect a little on what Tyndall calls the *perniciousness of authority.*

Prof. Tyndall, in the preface of his work on Sound, making special reference to Prof. Henry, says:

"And here a word might be said with regard to injurious influence still exercised by authority in science. The affirmations of the highest authorities that from clear air no sensible echo ever comes, were so distinct that my mind for a time refused to entertain the idea. Authority caused me for weeks to depart from truth and to seek counsel among delusions. * * *

* * * * * * * *

But though it thus deflected me from the proper track, shall I say that authority in science is injurious? Not without some qualification. It is not only injurious, but deadly, when it cows the intel-

lect into fear of questioning it; but the authority which so merits our respect as to compel us to test and overthrow all its supports before accepting the conclusion opposed to it, is not wholly noxious."

According to the statement of Mr. Bell in one of his letters,* when he called upon Prof. Henry, he announced to him that he (Prof. Bell) had heard a sound from a coil of wire having no interior core.

According to his account, Prof. Henry was so surprised and interested by this fact, that he proposed at once on a cold day to take a carriage and drive to some distant place where this might be seen.

And yet we know that this phenomenon had been observed by De la Rive and others years before, and had probably been known at the time to Prof. Henry, who, perhaps, had no occasion to investigate that particular phenomenon, or whose memory had failed to retain the fact.* Nevertheless the fact was so, and being an extension of the experiments of our own Dr. Page, and many other investigators all over the world, whose reports were printed in leading scientific journals, it proves

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* From Bell's letter to his father and mother, of March 18th, 1875, Mol. Rec., 1601.

"* * * Now to resume telegraphy. When I was in Washington I had a letter of introduction to Prof. Henry, who is the Tyndall of America. I had found on inquiry at the Institute of Technology that some of the points I had discovered in relation to the application of acoustics to telegraphy had been previously discovered by him. I thought I would, therefore, explain all the experiments, and ascertain what was new and what was old. He listened with an unmoved countenance, but with evident interest to all; but when I related an experiment that at first sight seems unimportant, I was startled at the sudden interest manifested. I told him that on passing an intermittent current of electricity through an empty helix of insulated copper wire a noise would be heard proceeding from the coil similar to that heard from the telephone He started up—said, "*Is that so?* Will you allow me, Mr. Bell, to repeat your experiment, and publish them to the world through the Smithsonian Institute, of course giving you credit of the discoveries?"

that all things were not necessarily untrue which, in 1876, surprised Sir William Thomson and Prof. Henry.

* "x-Int. 248. In your letter of March 18th, 1875, * * * you speak of telling Prof. Henry" that on passing * * * did you ever afterwards learn that that fact had been observed already by someone before you?

"Ans. I did. I found that this fact had been discovered by De la Rive. It is referred to in a paper by him in the 'Ann. de Chim. et de Phys.,' 3rd Series, Vol. XVI., p. 104."

TWELFTH.

Make and Break. Continuous Current.

When a battery is used, the current employed with the Bell magneto apparatus, Fig. 7, is necessarily a continuous current. The circuit—that is, the metallic connection of battery with transmitter, transmitter with receiver, and receiver with the earth, constitute a circuit incapable of being opened.

In such a circuit there can be no make and break of the current. If a permanent magnet is used in place of a battery, there will be a reversal in direction of the current at each similar reversal of direction in movement of the armature, and, logically (as current is the momentary effect of armature movement), an infinitesimal cessation of current at each arrest of movement preceding a reversal.

In any variable resistance circuit in which the loose contact of the microphone is employed, there is a constant liability to complete separation of the surfaces of the contact points.

A separation of surfaces to an extent beyond the power of any ordinary observation, and for a period of $\frac{1}{20000}$

to $\frac{1}{10000}$ of a second would be sufficient to make a break in the current.

See Prof. Cross, N. J. McDonough Case, Int. 46, Pamphlet.

Such a break (giving to his words the significance which they would have if used at the present time, about which we cannot be entirely certain, however), Reis thought occurred at the end of each sonorous vibration—that is to say, upon the completion of the air particle excursion.

Whether this is true or not during speech transmission is still a matter of doubt. Upon this question Prof. Cross says:

Cross-Int. 340. Then, according to your present knowledge, you think it possible, do you not, that the telephonic circuit may be broken at least once for each principal vibration of the transmitting diaphragm without destroying similarity of form between the electrical undulations and the air waves?

Ans. I am not ready to say that it is impossible under all circumstances.

Upon the question of what takes place at the contact points of a microphone transmitter when transmitting—in other words, whether there is ever an entire separation, or only a partial separation at all times when good transmission is taking place, is also a matter of doubt.

See Prof. Brackett, **O.**, p. 871; Prof. Young, **O.**, p. 806; Dr. Channing, **O.**, p. 974.

The opinion of Prof. Cross is as follows:

"It is of no importance whether the characteristic similarity in form between the air waves and electrical waves is produced by the variations in electro-motive force due to a magneto-transmitter; to the variations in resistance caused by a microphone or other battery transmitter; or, if such a thing were possible, *by a series of excessively minute breaks produced by a circuit-breaking transmitter.* If by any form of transmitting telephone those characteristic variations in form to which the quality of a sound is due are impressed upon an electrical current so that the electrical undulations are

similar in form to the sound waves which act upon the transmitter, the method employed is that invented by Mr. Bell, as distinct from the method used by Reis" (N. J. McDonough Case, Int. 50, p. 145).

That speech can be transmitted by a closed circuit and continuous current is manifestly proven by Bell's magneto apparatus. That that is not a good way is manifest from the fact that it is wholly abandoned, and the variable resistance method adopted in its stead.

That speech cannot be transmitted when the current is not continuous, is *not* proved. It is surmised by Prof. Cross, and doubted by many others.

See further citations on this subject at pp. 373–378.

The Court is now by the form of the complainant's contention, asked to assume this fact as if it were proved—while it still remains a subject of dispute among physicists.

That undulations in continuous electric currents occur when speech is transmitted, is also *not* proved.

It is undoubtedly proved that *something* occurs which has an agency in the reproduction of sounds. Whether it is some variation of the intermolecular relations of the conducting medium, brought about by attaching the conductor to a source of electricity; or a change in the tension of whatever is the product of battery or magnet and therefore called electrical; or whether it is some other occult process, as yet unrecognized, which results in allowing motion to be transferred and reproduced, we do not know. The manifesto of Mr. Bell's claim of merit as a discoverer gives us a simple formulation. It is—"Mr. Bell found out that undulatory currents of electricity, when similar in form to air vibrations, *can* act effectively in procuring the reproduction of the sounds accompanying those vibrations."

Mr. Bell has chosen, in stating his discovery, to limit

it to what he calls "electrical undulations." If there are no such limitations then he has not discovered anything, so far as his patent claim is concerned. If there is doubt, then just so far, it is doubtful whether his patent and his discovery agree. What he really discovered, and can prove—still assuming, for argument's sake, but not admitting it as a matter of fact the novelty of the discovery—is that speech is transmitted by the agency of electricity. But the case of O'Reilly vs. Morse would not permit him to patent so broad a discovery. What he has done, therefore, is to postulate an assumed action or condition of electricity under and by which it does that work—and patent that. If the existence of that action or condition could be proved in the judicial sense (which means, by responsible proof, on which somebody can be sent to jail if the proof is untrue), he would be near having a claim like the sustained 5th claim of the Morse patent.

Since it cannot be proved, and its inferential authority is disputed, his own 5th claim must be sustained, if at all, upon a more general form of statement, which at once establishes an "all four" similitude to the rejected 8th claim of that patent—something like the following:

A. Mr. Bell sets certain agencies in motion.

B. These agencies produce X; which represents whatever (not cognizable by any sense) takes place between the original air vibration (cognizable by the sense of hearing) and the reproduced air vibration (similarly cognizable).

C. X transmits telegraphically the sound, and we name it "electrical undulations similar in form," etc.

D. This naming is, however, only an expression of the present conception of science concerning X, and we do not hold ourselves responsible for its truth. We want a patent for X, however, whether the name is correct or not.

Thus stated—and such a statement is a logical necess-

ity of the position taken in giving a broad construction to claim 5—the complainants ask the Court to be responsible in their place for the truth of their theory, and guarantee its correctness, by (1) giving them a broad claim to electricity, under the guise (real or unreal) of certain actions or conditions thereof, which, if they exist, are the whole thing—or, if they do not exist, are a merely conventional expression for whatever else does exist; or (2) by abandoning all previous adjudications and giving them a broad claim to X, as the cause of speech transmission—simply because *it* exists indubitably, whether it stands for continuous electrical undulations similar in form, or any other of the discovered, undiscovered, discoverable or undiscoverable processes of nature.

That Mr. Bell and his experts are wrong, and that the proximate cause of speech transmission may hereafter be found to be, *not* the *similarity in form* of the undulations, etc., is not only not impossible, but in view of the many instances in which scientific theories as reasonable and as strongly upheld as the present undulatory theory of electricity have proved untrue, is not highly improbable.

The theory of Sir Isaac Newton concerning light, known as the emission theory, which is now entirely abandoned for the wave theory, may be referred to. Suppose at some date prior to 1815 when the undulatory theory under the teaching of Young overcame the corpuscular, or emission theory sustained by the great name of Newton, photography had been in existence, and the Court of Chancery in England had been called upon to restrain the general practice of that art upon the assumption that the emission theory was true, and that the heirs of Sir Isaac Newton had an interest in that process of nature by right of discovery. No greater name and no higher authority than that of Sir Isaac Newton could ever be adduced in the support of

any hypothetical claim of science; and if scientific hypothesis could ever afford support to a judicial judgment, it would be in such a case.

Let us conceive, however, of the feeling and position of a judge who should have taken from one man his property or rights and given them to another, upon a judicial judgment that that theory *was* true—on receiving news that that basis of his judgment had lost all credit in the scientific world!

The possibility of such a state of things should be a sufficient warning to Courts of Justice to limit their investigations to such exact and provable means of knowledge as are appropriate to judicial inquiries.

The entire body of proof upon this subject may be considered as summed up by Prof. Cross as follows:

"Cross-Int. 115. Do you regard it as a physical law that a telephone can operate in the transmission of speech *only* by means of electrical undulations substantially similar in form to the air waves that actuate the transmitter?

"Ans. * * * I have not succeeded in thinking of any other way of doing this, and it does seem to me to be a necessary though not an immediately evident consequence of natural laws" (New Jersey McDonough Case, p. 163).

It is respectfully submitted that proof thus qualified and doubted is not adequate to support a judicial judgment (affecting important property rights), that the electric current used in a microphonic telephone transmitter is either continuous or undulatory.

THIRTEENTH.

Other anticipations which influence the state of the art and limit Mr. Bell's claim.

I.

Doctor Wright's Apparatus.

We have already shown that previous to 1867 Doctor Horace S. Wright, of Edinburgh, Scotland, used an induction coil as an adjunct to a sound transmitting apparatus in connection with a Reis transmitter.

In an article (Transactions of the Royal Scotch Society of Arts 1860–1864, Vol. 6, Appendix, 185–187) it is stated that Doctor Wright showed and described a condenser, consisting of plates of zinc slightly curved and separated by sheets of insulating paper, which produced loud sounds and musical tones when coupled with the secondary wires of an induction coil.

Subsequently Doctor Wright used a condenser formed of two sheets of paper, silvered or covered with thin metal foil, placed back to back.

Dolbear Circuit Record, pp. 256, 257, 268, 269, 270, 275, 290.
Ferguson on Electricity, 1867, p. 68.

In "Ferguson on Electricity" the apparatus employed by Doctor Wright is described as follows:

"The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he placed two sheets of paper, silvered on one side, back to back, so as to act as a condenser. Each current which comes from the sending apparatus produces a current in the secondary circuit, which charges and discharges the condenser, each discharge being accompanied by a sound like the sharp tap of a small hammer. The *musical* notes are rendered by these electric discharges, and are loud enough to be heard in a large hall."

Professor Charles R. Cross in an affidavit made by him in behalf of the appellees herein (Dolbear Circuit Record, p. 84), refers to the Wright condenser and its use as follows:

"That the attractive power of one plate on another varied with the electrical condition of the first, was well known before the date of Mr. Bell's said first patent; it was also well known before the date of said patent that by this means the electrical variations in the secondary circuit of an induction coil could be made to cause such vibratory motion in a plate as to thereby produce a sound whose pitch corresponded to the rate of the electrical variations. And this device for converting electrical variations into sound waves was well known as an equivalent and substitute for the motion given to a vibrating armature by means of the varying attraction of an electro-magnet, through whose coils the same varying current should be passed."

In a subsequent affidavit made by Prof. Cross (Dolbear Circuit Record, pp., 256–257), commenting on the above quoted paragraph, he says:

"In my first affidavit in this case I referred to the fact that previous to the date of Bell's patent electrical variations in the secondary circuit of an induction coil were utilized to produce sound by causing vibratory movements in plates. * * * I had in mind three particular pieces of apparatus: First, the receiver of Dr. Wright described by him in an article in the 'Transactions of the Royal Scotch Society of Arts,' 1860-1864, Vol. 6, Appendix, pp. 185–187; second, a somewhat different condenser-receiver of Dr. Wright described in 'Ferguson on Electricity,' 1867, p. 68.'"

In a subsequent part of the same affidavit (Dolbear Circuit Record, p. 264), referring to the Wright and Varley condenser-receivers, Prof. Cross says:

"I have tried them many times for that purpose. I find that a small Wright condenser of his first form made with zinc plates and enclosed in a case, similar to that used by Mr. Bell for his telephones, compares very favorably in its performance with one of the Dolbear receivers which I have already described, and that the larger condenser of Wright, constructed as directed in his article in the 'Transactions of the Royal Scotch Society,' will readily reproduce speech."

Again when testifying as to the substantial identity of the Dolbear and Wright receivers (Dolbear Circuit Record, pp. 256), Prof. Cross states that

"The condenser *as a source of sound* was by Mr. Varley substituted for a magneto-receiver as an equivalent for it. So Dr. Wright substituted his condenser in the Reis apparatus for the magneto-receiver used by Reis, *as a means of converting into sound electrical vibrations (undulations) produced by the voice.*"

Prof. Arthur W. Wright, an expert witness for the appellees (Dolbear Circuit Record, p. 290), states that

"Previously to 1867 Dr. Wright, of Edinburgh, showed ('Transactions of the Royal Scotch Society of Arts,' 1860-64, Vol. 6, Appendix, pp. 185-187. Ferguson, 'On Electricity,' 1867), that a condenser formed of two sheets of paper, silvered or covered with thin metal foil, placed back to back, or of thin plates of zinc slightly curved and separated by sheets of insulating paper would produce loud sounds when connected with the secondary wire of an induction coil. These condensers reproduce musical sounds, and both forms are suited to reproduce *articulate speech* so that it can be readily understood, and will do so, as I know from repeated experiments with condensers of the same constructions."

The description of Dr. Wright's apparatus and its mode of operation, when taken in connection with the statements and admissions of Professor Cross and Wright, and the evidence adduced in this case concerning the Reis apparatus and its mode of action, clearly establishes:

1. That Dr. Wright used an apparatus consisting of a primary circuit included in which was a battery, a Reis variable resistance transmitter and the primary helix of an induction coil provided with a secondary helix, the wires of which were suitably connected to the plates of a condenser receiver.

2. That Wright substituted his condenser in the Reis apparatus for the magneto receiver used by Reis, as a means of converting electrical vibrations into sound vibrations, or undulations, *produced by the voice.*

3. That a Wright condenser will transform electrical

variations, or undulations similar in form to the sound waves into corresponding sonorous vibrations, and thereby produce sounds and articulate speech.

4. That by Wright's method a transmitting diaphragm was set into vibration by the impact of air waves produced in any manner, thereby causing in the battery circuit a corresponding variation of resistance and consequently a corresponding variation of current. This variation of current caused corresponding variations of magnetism in the core of the induction coil, which in turn induced corresponding magneto currents (undulations) in the secondary helix of the coil, which passing through the secondary wire to the condenser plates vibrated them and thus transformed the electrical variations or undulations into sonorous vibrations and sounds.

It is, therefore, obvious that Mr. Bell was not the first to utilize the sound waves or motion of the air particles at the transmitting station to move a diaphragm there placed, whose motion in turn served to vary the electrical condition of the line wire leading to a receiver; nor was he the first to transform electrical undulations similar in form to the sound waves into corresponding sonorous vibrations and thereby produce musical sounds and articulate speech. Messrs. Cross and Wright, in their depositions, from which the above quotations were made, state that Dr. Wright's apparatus was capable of transmitting *pitch*—that is, simple musical tones. But it has already been shown that the Reis apparatus will transmit and reproduce articulate speech, and Professors Cross and Wright both admit that the condenser-receiver of Dr. Wright, when properly coupled in a telephonic circuit such as he used, will reproduce articulate speech. Manifestly the electrical variations produced in the secondary circuit of the Wright induction coil were *undulatory* in character —if the defendants are undulatory—and so moved or vibrated the condenser plates as to produce correspond-

ing sonorous vibrations and sounds at the receiving station.

II.

Van der Weyde.

Mr. Van der Weyde, at an early date, made some interesting experiments with the Reis telephone. His only information of the Reis invention was derived from Hessler's article (Record, p. 287, answers 132–3), an article which does not allude to the invention as intended for or capable of transmitting speech.

Dr. Van der Weyde constructed a number of instruments. They were somewhat different in form from those constructed by Mr. Reis. Two forms of transmitters are shown, in one of which a tin box is used, and in the other a wooden box; both the tin and the wooden boxes had devices in the shape of screws for adjusting the contact between the needle and the strip underneath it which lay upon the diaphragm. It will be noticed that Dr. Van der Weyde's transmitters were constructed with a tubular mouthpiece. The Doctor also constructed several receivers. His first receiver consisted of a quite long iron bar, wound with wire, the end of which was close to a metal diaphragm fastened all around the edges and circular in form. His other receiver consisted of a horseshoe magnet similarly wound with wire, and the poles of which were opposite to a circular metal disk mounted in a frame. The Doctor gave public exhibitions of the use of these instruments, and with them transmitted tunes and words which were heard by many persons. That he did transmit tunes would seem beyond question on the evidence in the case. Many witnesses testify that when the transmission was of songs they

not only recognized the tunes, but also the words which were sung. The testimony of Dr. Van der Weyde and of the witnesses who testified about his machine is found on page 259 of Record, *et seq.* On page 260, the doctor says that he had found the description of Reis' telephone in Hessler's text book of physics; that as Hessler does not mention the possibility of transmitting speech, but only mentions it as a telephone to transmit musical tones, and being a musician, the doctor had for a long time been contemplating if music could not be transmitted by electric currents; that his whole attention was directed in that direction, and that all the improvements made by him were calculated to make the transmission of music more perfect. When the instruments were finally ready, he exhibited them at a meeting of the Polytechnic Club of the American Institute, in room 24, Cooper Union, January 7, 1869. He says that as far as he remembers on that occasion the experiments were confined to the reproduction of the human voice, while he was giving his exclusive attention to the correct reproduction of the melody; he cannot remember who sang, but some of the members present volunteered to sing at the other end of the line. They sang parts of popular songs, such as "Auld Lang Syne" and "Home, Sweet Home," and the reproduction was quite satisfactory to him, being correct, except that the pitch of some tones was louder than that of others. He says that some of the parties present who listened stated that they could distinguish the *words* of the song, but that his prejudice was so great against that, that he ascribed it to imagination, giving his special attention to the musical qualities of the tone. The doctor himself says that he listened at the receiver and heard the singing and that it sounded like a human voice, but rather nasal (page 263). The doctor further says that in August, 1870, he gave an account of his improvements in the way of

transmitting musical melodies at the Troy meeting of the American Association for the Advancement of Science, and that there somebody suggested the use of an iron diaphragm, or tinned iron, instead of the brass plate, in front of a horseshoe magnet. He says that in addition to the transmitting of melodies sung by the human voice, he experimented by the tones of the violin, flute and loose organ pipes, and he says that in using the different instruments mentioned to actuate the transmitter, he could distinguish one instrument from another (pages 268–269).

We desire here to call the attention of the Court to the fact that one instrument could be distinguished from another by means of the telephones used by Dr. Van der Weyde. That being so, those instruments must have transmitted what is called quality; because the only difference in a note sounded by one instrument and another is that difference which is called quality, which consists in the number and variety of over-tones which are transmitted with the fundamental. If, then, these instruments used in America, publicly used in an exhibition, did actually operate to transmit the tones of the various instruments so that the instruments could have been distinguished and were distinguished one from another, the thing must have been done, according to complainants, upon the same principle and upon the same theory, or upon the same process or method described in Mr. Bell's patent, to wit, by creating electrical undulations upon the line-wire which corresponded in form with the aerial vibrations which actuated the transmitter. Dr. Van der Weyde says that at the meeting on January 7, 1869, a number of persons, whom he mentions, told him that they heard and understood the words of the song (see page 270). Mr. Blanchard, on page 318, testifies that he was one of those who were present on the occasion of January 7, 1869, referred to. He states how he came to be called as a witness in answer to the 14th cross-interrogatory on page 320: That about four

or five weeks prior to the date of his examination Dr. Van der Weyde made a public inquiry at a meeting of the Polytechnic Association of the American Institute if there was any person present who remembered his exhibition of the telephone. "I told him I remembered it." The subsequent witnesses make substantially the same statement, saying that they were produced and examined simply because in answer to that public inquiry of Dr. Van der Weyde at a meeting of the association, he asked for persons who had been present at his exhibition in January, 1869, and they responded.

Mr. Blanchard says in answer to the 9th interrogatory that he heard when listening at the receiver, the tones of the violin dimly, faintly; he took it to be a violin. He heard also a tune or part of a tune sung by some person, and heard the words faintly but still distinctly.

Mr. John R. Hudson, on page 324, says he heard tunes and could recognize the sound as proceeding from the human voice.

Mr. Benjamin Finnell, on page 327, says he could distinguish the sounds as those of the human voice and could and did distinguish words.

Mr. Albert Hatch, page 337, listened at the receiver; he talked or sang into the transmitter; he heard the strains of the old plantation song, the "Old Folks at Home" and recollects hearing "Way Down upon the Suwanee River."

Mr. Nicholas Johnson (pages 332-3), was there but did not listen, but heard people standing near the receiving instrument saying that they could hear and distinguish the sounds in that instrument.

In addition to these witnesses, there is the testimony of Mr. Frederick M. Vietor, who testified to having been a pupil of Mr. Reis and to having witnessed some of Mr. Reis' experiments with his telephones, wherein Mr. Reis explained to his pupils that the words or sounds spoken into the instrument resembling the ear

at the other end would be carried by the electricity to this box, which he supposed was called a receiver, and there heard audibly.

The instrument and the experiments therewith disclosed in this testimony of Dr. Van der Weyde and the persons who witnessed his experiments conclusively show that speaking telephones were manufactured and used publicly at that time, and that they did publicly transmit speech better than anything done by Mr. Bell until long after the date of his patent No. 174,465.

In addition to the actual results produced we have the testimony of Dr. Van der Weyde that he observed and acted on the fact that *the best* results were obtained " with a slight permanent contact " (p. 288).

The doctor says, p. 287 : " If I had seen those German journals which gave a correct account of what Reis had done and how he had done it and what he had accomplished I would never have been so much in the dark as to suppose that his telephone would not transmit speech ; but as I say, having the misfortune of believing in Hessler, I believed, wrote and published the opinion that Reis' telephone could only transmit music and not spoken words." And further down the page : " This statement of Hessler prevented me to carefully notice what took place in my transmitters, which is not a separation of the platinum parts, but a closer compression. In fact by speaking in the mouthpiece the vibration of the air in the box presses the membrane with the platinum foil more closely against the platinum point over it ; in that way alternately increasing and decreasing the conductivity of the parts and consequently causing a fluctuating of the currents.

" It is Hessler's fault that I was blind for this observation."

" Finding as I did, that it was not necessary to keep the point at the small distance from the membrane, this position of the point gave me in fact a snarly re-

production of the pitch, *while a slight permanent contact gave me the best results.*"

Thus we have the modern microphone in *actual use* in this country according to the modern method long prior to the Bell patent and to any pretense of Bell's invention or conception—in use in a far more definite and public way that either the hinge or the safe lock in the *Hinge or Safe Lock* cases.

Whether the true explanation or theory were given is of no consequence. The so-called method of producing undulations similar in form was there. It was found to produce the best results and was used publicly long before the earliest date Bell gives to his conception.

III.

The Varley Patent.

On the 8th day of April, 1870, British Letters Patent numbered 1044 were granted to Cromwell Fleetwood Varley, of Beckenham, England, for improvements in a system of harmonic multiple telegraphy.

The patent referred to will be found in the Dowd Circuit Record, pp. 546–566; Dolbear Record, pp. 633–642; **O.**, pp. 3642–3658.

The Varley "invention has for its object the increase of the transmitting power of telegraph circuits by enabling more than one operator to signal independent messages at the same time upon one and the same wire to and from independent stations."

Referring to his method and apparatus Mr. Varley says:

"By my invention I superpose upon the currents used for work-

ing the ordinary telegraphs rapid *undulations** or waves which do not practically alter the mechanical or chemical power of the ordinary signal currents, and by new apparatus hereinafter described, these undulations are made to produce distinct and independent audible or other signals so long as these undulations are produced, whether ordinary signal currents be flowing or not" (p. 554); **O.**, p. 3647.

Among the claims in the Varley patent are the following:

"Having thus described the nature of my invention, and the manner of performing the same, I would have it understood that I claim the construction of electric telegraphs in such manner that current signals and wave signals may be simultaneously transmitted through the same line wire and may be rendered sensible at the receiving station by separate instruments, the one sensitive to currents of appreciable duration and the other to electric waves or vibrations.

"I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a strained wire, a tongue," (equivalent to Bell's armature) "or such like instrument adjusted to vibrate in unison with the electric waves, and being magnetized by them oscillating to and from the pole or poles of a magnet in its vicinity.

* * * * * * * *

"I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a condenser consisting of thin sheets capable of being agitated by such waves" (pp. 5645); **O.**, pp. 3657–8.

The drawings of the patent show and the specification thereof describes an ordinary Morse telegraph circuit, provided with sending keys for Morse signals, and a battery having suitable connections with such keys and with the earth.

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* This is believed to be the first use of the term "undulation" to signify an electrical variation. The adoption of this name by Mr. Bell has helped on the misconception—in which he was himself at one time involved—that he had invented the undulatory current.

The wave signal apparatus, which is to be used in connection with the ordinary telegraph circuit and apparatus, consists essentially of an induction coil, the primary circuit of which includes a battery, an electro-magnet and a tuning fork which is caused by the currents from the battery to vibrate between two contact points, and thus alternately open and close two branches of a primary circuit, which include two primary coils wound in opposite directions around the core of the induction coil, upon which a secondary wire is also wound. The two primary helices are wound in opposite directions in order that currents may alternately flow through them and so that the polarity of the core of the induction coil will be reversed at each alternation of current. A Morse sending key is placed in the secondary circuit of the induction coil. One terminal of the secondary wire of the induction coil is connected to the earth and the other to the hammer-anvil of the finger-key. The stop-anvil of the key is connected by a wire to a cymaphen, or acoustic receiver, and to the earth. A condenser made of paper and metal foil is employed at the transmitting station, and is interposed between the sending key and the line wire; one plate of the condenser being connected to the key and the other to the line. The wave signalling apparatus at the receiving station consists of a condenser similar to that at the transmitting station, one plate or armature of which is connected to the line and the other to a cymaphen, or acoustic receiver, which latter has also suitable earth connection.

The cymaphen, or acoustic receiver, consists essentially, of an iron frame containing a sounding board, and is provided with bridges at the ends of which a hard drawn iron or steel wire is stretched from one end to the other, and is strained so as to sound the same note as the tuning fork of the sending instrument. The wire passes through a hollow helix of insulated copper wire, the helix being attached to the frame

supporting the sounding board, but not touching it. Two horse-shoe magnets are placed one on each side of the wire. The specifications say that :

" The currents magnetize the wire inside the helix, and so cause it to be attracted and repelled from one magnet to the other. When the wire is properly tuned so as to vibrate synchronously with the apparatus at the distant end, making the alternations in the current, the sound from very feeble currents is distinctly audible " (p. 557 ; O., p. 3650).

In the specification of the patent it is also stated that :

" The sounding board (of the acoustic receiver) may be replaced by a *strained* diaphragm, or a drum-head, on which one of the bridges over which the wire is strained is supported ; this arrangement gives a better sound with very feeble currents, but with moderate currents the sounding board appears to have the advantage " (p. 557 ; O., p. 3650).

When the key at the transmitting station is depressed the condenser is put into electrical connection with the secondary circuit of the induction coil and the wave generating apparatus. The induced currents generated in the secondary wire of the coil are conveyed to one plate or set of plates of the condenser at the transmitting station and pass through it by induction and to and over the line wire to the condenser at the receiving station then inductively affecting or passing through that instrument to the ground, operating the cymaphen or acoustic magnet receiver on their way. Mr. Varley proposes to utilize these undulatory currents to work acoustic magnetic receivers of various forms. The specifications say :

" There are various ways in which the wave signal receiving apparatus may be constructed, * * * , thus the condenser itself may be the receiving instrument." (p. 559 ; O., p. 3652).

The condensers themselves may be used for *producing* sound as the following extract from patent will show :

"The first or communicating station produces in its condenser rapid charges and discharges; these add to and take from the line a number of small electric impulses without affecting the mean magnetizing power of the current through the line. These impulses charge and discharge the second condenser at the other end. These undulations in the second condenser can be utilized in the following manner:

"FIRST. If the condenser be made of paper and metal foil the rapid charges and discharges produce a musical sound.

"SECOND. If those rapid alternations be made to pass round a helix containing an iron rod a musicial sound is produced" p. 550; O., p. 3643).

Again the patentee says:

"If a steel tongue, (armature) similar to one of those used in a musical box, be magnetized and placed inside a helix of fine wire, and its lip is placed between the poles of a powerful permanent magnet, the alternating currents will cause the tongue to vibrate and produce a musical sound so long as the alternations are operating."

Further on in the specifications it is stated that

"Vibrations are rendered sensible by placing a movable iron bar between the poles of an electro-magnet or inside a helix, and one or both of its ends between the poles of permanent magnets; * * * The vibration of the currents cause it to vibrate between the poles of the electro or permanent magnets and so produce distinctly audible sounds" (p. 560; O., p. 3653).

The Varley condenser is made of alternate sheets of tin-foil and dry paper, and in the specification of the patent it is said that:

"Such a condenser, consisting of from 20 to 50 sheets, will be found to be much agitated and to produce a loud note with five hundred alternations of current per second, if the potential be 50 to 100 volts" (p. 559; O., p. 3652).

The patentee also suggests the use of two or more tuning forks as an apparatus by which electric waves may be generated. The specification says that two sets of wave signals may be transmitted and received simultaneously through the same wire and independ-

ently of the current signals, if a sufficient difference be made in the periods of the two sets of waves. Thus if waves of 200 vibrations in the second, and waves of 850 or 900 vibrations in the second, be simultaneously transmitted and received by two separate cymaphens, the one adjusted to the slow, and the other to the rapid vibrations, they may be separately read, as the vibrations which affect the one are inoperative upon the other. Morever, the specification referring to figure 8 states that "By using these instruments, these appatus together with cymaphens, as is shown in figure 8, three messages can be sent from end to end of such a circuit at the same time independently of each other."

In addition to a transmitting apparatus, consisting of a tuning fork and an electro-magnet, the specification sets forth that there are several other methods of producing electric waves in the line. A tongue similar to those used in harmoniums is made to vibrate by *air* between contact points and so connect the condenser alternately with the battery and with the ground. Obviously a series of tuning forks or vibrating reeds, capable of producing musical notes of different pitch could be employed in the Varley wave signalling apparatus, whose tones being transmitted to the condenser-receiver would thus produce harmony and melody. It is also stated in the patent that

"A magneto machine rapidly rotating will do the above duty" (that is, produce electric waves in the line) "equally as well if its speed of rotation be controlled by a good governor. The tuning fork and vibrating tongue arrangement can be set to and can keep up any desirable rate of vibrations" (pp. 552-3; **O.**, p. 3646).

In the Dolbear case (Dolbear Record, page 256) Prof. Cross says:

"In my first affidavit in this case I referred to the fact that previous to the date of Bell's patent, electrical variations in the secondary circuit of an induction coil were utilized to produce sound by causing vibratory movements in plates. In this statement the

defendants consider that I was mistaken. I had in mind three particular pieces of apparatus. * * * Third, the condenser described by Varley in his English patent No. 1044, of April 8th, 1870. * * * In the Varley apparatus one plate of the condenser was connected to one terminal of the secondary helix of an induction coil, while the primary circuit was made and broken by a tuning fork or other suitable arrangement. The purpose of the Varley was to reproduce in this receiver the pitch of the transmitter in a system of harmonic multiple telegraphy.'

Prof. Cross quotes Mr. Varley's description of his condenser, wherein he says :

" Impulses however passed through the condenser or the induction coil used, or both, and operated various forms of magneto-receivers to produce musical notes corresponding to the rate of interruption by the tuning fork transmitter."

On page 260 of the Dolbear Circuit Record, Prof Cross states that the Varley condenser may be used as a telephone receiver, and on page 264 of the same Record he says that "the Varley condenser, *constructed as in Mr. Varley's patent* already referred to *is capable of reproducing speech.*"

Again, at page 465 of the same record, Prof. Cross says: "That *the condensers* (Varley and Wright) *made before 1876*, or directed to be made, for the purpose of transforming electrical variations into sound waves, *will to-day transform electrical undulations similar in form to sound waves into corresponding sonorous vibrations, and thereby produce articulate speech.*"

In the Dolbear Circuit Record, page 287, Prof. Arthur W. Wright refers to the Varley patent and to the apparatus therein described, as follows :

" In the year 1870 Mr. C. F. Varley obtained a patent (English Patent Number 1044) for a telegraphic apparatus in which the sound transmitted by a condenser was utilized. In this system the current from a battery traverses the primary wire of an induction coil. The induction currents generated in the secondary wire of the coil are conveyed by a wire from one of its poles (the other being grounded) to one plate or set of plates of a condenser. The other plate of the condenser is connected to a line wire. At the other

end the line wire is connected to one terminal of a condenser at the receiving station, the remoter terminal of this condenser being connected to the ground."

He then shows by diagram the arrangement of the Varley apparatus and conductors, and says that:

"Mr. Varley's statement of the operations was that the signals sent by the Morse key K, would work the Morse receiver S, but were not sufficiently sharp and rapid to produce effects on or through the condensers. On the other hand, the rapid and sharp 'waves signals' sent by the harmonic transmitter C B (tuning fork and electro-magnet), which broke the circuit several hundred times a second, would pass through the condenser C by induction, would reach the point J, would not be able to effectively pass the sluggish electro-magnet E M, but would pass to the condenser C^1, then inductively affect or pass through that instrument to the ground, operating the acoustic magnet receiver on its way."

"Confining our attention to what Mr. Varley calls the 'wave signals,' which are those sent from the induction coil I C, and which operates the receiving condenser C^1, or the receiver (cymaphen) A R, we find that in this apparatus the electrical impulses produced by induction in the secondary wire of the coil alone pass over the line wire, as no part of the battery current can enter it. Mr. Varley proposes to utilize these currents to work *acoustic magnetic receivers* of *various forms*, for which they are well suited."

Furthermore, on page 290 of the Dolbear Record, Prof. Wright states that:

"These condensers (Varley and Wright) *reproduce musical sounds*, and *both forms are suited to reproduce articulate speech* so that it can be readily understood, and will do so, as I know from repeated experiments with condensers of the same construction."

IV.

A comparison of Varley and Bell.

Having described the method and apparatus set forth in the Varley patent, we will now—and at this place—compare the same with the method and apparatus of Mr. Bell's patent No. 174,465.

Mr. Varley's patent sets forth a system of harmonic multiple telegraphy.

Prof. Cross, Dolbear Circuit Record, p. 257.

The specification of the Varley patent recites that its objects is to increase the transmitting power of telegraph circuits by enabling more than one operator to signal independent messages at the same time upon one and the same wire to and from independent stations.

In another part of the specification it is stated that:

"Two sets of wave signals may be transmitted and received simultaneously through the same wire, and independently of the current signals if a sufficient difference be made in the periods of the two sets of waves.

"Thus, if waves of 200 vibrations in the second, and waves of 850 or 900 vibrations in the second, be simultaneously transmitted and received by two separate cymaphens, the one adjusted to the slow, and the other to the rapid vibrations, they may be separately read as the vibrations which affect the one are inoperative on the other."

Again, the specification recites that:

"By using these instruments, these apparatus together with cymaphens, as is shown in figure 8, three messages can be sent from end to end of such a circuit at the same time independently of each other."

In the first claim of Mr. Varley's patent, he says:

"I would have it understood that I claim the construction of the electric telegraphs in such manner that current signals and wave signals may be simultaneously transmitted through the same line wire, and may be rendered sensible at the receiving station by separate instruments, the one sensitive to currents of appreciable duration and the other to electric waves or vibrations."

Thus the Varley patent shows and describes a system of multiple telegraphy whereby a number of telegraphic signals can be sent simultaneously over the same circuit in either or in both directions.

Mr. Bell's first patent also describes and claims a system of multiple telegraphy. In his second patent, No. 186,787, he refers to the method and apparatus contained in his first patent as follows :

" In Letters Patent, granted to me March 7, 1876, number 174,-465, I have shown and described a method of an apparatus for producing musical tones by the action of undulatory currents of electricity, whereby a number of telegraphic signals can be sent simultaneously over the same circuit in either or in both directions," etc.

In the specification of the first patent, Mr. Bell says :

" In illustration of my method of multiple telegraphy I have shown in the patent aforesaid, as one form of transmitting instrument, an electro-magnet having a steel spring armature which is kept in vibration by the action of a local battery."

In another part of the specification of the same patent it is stated that

" The co-existence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory character of the current," etc. * * *

And again it is said that

" By these instruments (shown in Figs. 5 and 6 of the patent) two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another."

Referring to the instrument shown in Fig. 6 of the patent, Mr. Bell says :

" When two or more instruments of different pitch are simultaneously caused to vibrate all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting instruments with which it is in unison."

Hence, it is obvious that Mr. Bell's first patent, like that of Varley's relates primarily at least, if not—as we believe it does—*wholly*, to improvements in harmonic multiple telegraphy.

Mr. Varley, like Mr. Bell, employs vibratory or undulatory currents of electricity in the method and apparatus described and claimed in his patent. For example, he says:

"By my invention I *superpose* upon the currents used for work, ing the ordinary telegraphs, rapid *undulations* or waves, which do not practically alter the mechanical or chemical power of the ordinary signal currents, and by new apparatus hereinafter described, these undulations are made to produce distinct and independent *audible* or other *signals* so long as these undulations are produced, whether ordinary signal currents be flowing or not" (Dowd Rec.-p. 554; **O.**, p. 3647).

And again, in two of the claims, Varley refers to the employment of undulatory currents as follows:

"I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a strained wire, *a tongue* (armature) *or such like instrument adjusted to vibrate in unison with the electric waves*" (*Ibid.*, p. 564; **O.**, p. 3657). * * * "I also claim the construction of electric telegraphs with, at the transmitting station, *an instrument capable of originating in the line wire a succession of rapid and regular electric waves*, and at the receiving station *a condenser* consisting of thin sheets *capable of being agitated by such waves*" (*Ibid.*, pp. 564-5; **O.**, pp. 3657-8).

In Mr. Varley's method rapid waves or undulations are superposed upon the ordinary telegraph or battery current, thereby adding to and taking from the line current a succession of electric impulses without affecting the mean magnetizing power of the currents through the line. In other words, the magneto currents, which are induced in the secondary circuit of the induction coil of Mr. Varley's wave signalling apparatus being added to the line current alternately strengthen and weaken it, thus producing electrical undulations upon the line which passing to the condenser-receiver or to the acoustic receiver, are there transformed into corresponding sonorous vibrations and sound.

Although Varley speaks of his undulations as "regular," it is manifest that they are just what Bell's are, since they *will transmit speech.*

CROSS, *supra.*

The production of undulations by throwing a battery current into waves has been a favorite theory with Mr. Bell. For example, in a communication to the American Academy of Arts and Sciences, Dowd Record, page 28 (**O.**, p. 3455), he says:

"A steel tuning-fork, which had been previously magnetized, was caused to vibrate in front of the pole of the electro-magnet. A musical note, similar in pitch to that produced by the tuning-fork, proceeded from the telephonic receiver in a distant room."

"The effect was much increased when a battery was included in the circuit. In this case, the vibration of the permanent magnet *threw the battery current into waves. A similar effect* was produced by the vibration of an unmagnetized tuning-fork in front of the electromagnet."

"And here I may remark that, although the conception of the undulatory current of electricity is original with myself, methods of producing sound by means of intermittent or pulsatory currents have long been known" (Mol. Rec. p. 1999; **O.**, p. 2727).

In Mr. Bell's English patent (Third Plan, Dowd Circuit Record, p. 93) the specification recites that:

"When the permanent magnet is caused to vibrate in front of the pole of an electro-magnet which is placed in circuit with a voltaic battery, the undulatory current induced by the vibration of the permanent magnet is superposed upon the voltaic current. When the induced impulse is of similar polarity to the voltaic current it serves to strengthen the intensity of the latter, but when it is of opposite polarity it tends to neutralize the voltaic current. In such an arrangement the resultant effect of the vibration of the permanent magnet is to *throw the battery current into waves*, as in line 3, figure 6, by alternately increasing and diminishing the intensity of the current."

The apparatus shown and described in Mr. Bell's English patent is substantially like that set forth in his two United States patents numbers 174,465 and 186,787.

Now, referring to Mr. Bell's patent of March 7, 1876, we find that his

"Invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of, and apparatus for, producing electrical undulations upon the line-wire."

We have already shown that the apparatus set forth in Mr. Varley's patent employs an undulatory current of electricity and describes and claims a method of producing electrical undulations upon the line-wire. There is no substantial difference between the undulatory currents of Mr. Bell's first patent and that of Mr. Varley. Mr. Bell defines electrical undulations as resulting

"From gradual changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations."

"Simple pendulous vibrations" would produce simple sounds or musical tones like those of a tuning fork or harmonic transmitter, such as Mr. Varley employs in one form of his wave signalling apparatus. Simple pendulous vibrations would also induce in the line-wire electrical undulations or changes like those referred to in Mr. Bell's first patent—that is, they would be similar in form to the undulations generated by the apparatus shown and described in Figs. 5 and 6 of said patent. The action of the instruments in Fig. 6 is described as follows:

"When the armature of any one of the instruments is set in vibration, all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent."

The armatures employed in those instruments are therefore *tuned* armatures, and the receiving armature in vibrating produces a musical note of a

pitch corresponding to that of the transmitting instrument with which it is in unison. So in one form of the Varley apparatus the strained wire of the cymaphen vibrates synchronously with the tuning fork at the transmitting station, thus producing a corresponding note or sound. Hence it follows that so far as the production of undulations is concerned, there is no substantial difference between the electrical undulations generated by Mr. Bell's tuned armatures or reeds (Figs. 5 and 6) and the undulations caused by Mr. Varley's tuning fork and strained wire. Moreover, other modes of producing electrical undulations than a tuning fork are suggested and described in Mr. Varley's patent. He says that if the rapid alternations of current be made to pass around a helix containing an iron rod, the iron rod will issue a feeble but distinct sound." And again, the patent states:

"If a steel *tongue* (armature), similar to one of those used in a musical box, be magnetized and placed inside a helix of fine wire, and its lip is placed between the poles of a powerful permanent magnet, the alternating currents will cause the *tongue* (armature) *to vibrate and produce a musical sound* so long as the alternations are operating" (Dowd Rec., p. 560); **O.**, p. 3653.

In another part of the specification Varley suggests that a harmonium tongue (armature) may be vibrated by *air* between contact points, and so connect the condenser alternately with the battery and the ground.

Furthermore, Varley's patent states that

"a magneto-machine rapidly rotating will do the above duty (*i. e.*, generate electric waves) equally well, if its speed of rotation be controlled by a good governor.

In Mr. Bell's first patent a similar apparatus for producing undulations is described, to wit:

"When a cylinder, upon which are arranged bar magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet" (Mol. R., p. 51); **O.**, p. 43.

If the magneto-machine, referred to in Mr. Varley's specification, were interposed in the primary circuit of the induction coil, then it is clear that the rapid rotation thereof would produce electrical undulations in the secondary circuit like those described by Mr. Bell in his patent No. 174,465. Such an alternative transmitter would not necessarily interrupt the primary circuit in which it was placed, and in that event both the primary and secondary circuit of the induction coil would *always be closed* during the transmission and reproduction of sounds.

D'Infreville, Dowd Circuit Record, Vol. I., p. 607 ; **O.**, pp. 3392–3.

Hence, the electrical undulations, produced by the apparatus illustrated in figures 5 and 6 of Mr. Bell's first patent, are substantially like those employed by Mr. Varley in the apparatus set forth in his patent number 1044.

Furthermore, the substantial identity of the currents used in the two apparatus of Varley and Bell is proven by Prof. Henry Morton, who testified on behalf of the appellants in this case, as follows :

"I find in the English patent to Cromwell Fleetwood Varley No. 1044, dated April 8th, 1870, description of an apparatus for transmitting telegraphic signals, in which an undulatory current is employed, the said undulatory current being obtained from a magneto-machine rapidly rotated and having its rotation controlled by a governor. In this patent not only is it proposed to transmit a single set of signals over a wire by this means, but it is also proposed to transmit several signals at once over one wire by the use of such undulatory or wave currents ; the means of securing this multiple transmission being the adjustment in the wave length of the several wave currents, so that each of them shall operate upon a different receiver sensitive or responding to that wave length and not to the others." * * *

If the condenser-receiver were employed at the receiving station, it would respond to any wave length of

the currents transmitted to it, because it will reproduce articulate speech.

As to the identity of the current in the patents of Varley and Bell, he says :

> " So far as the mere fact that an undulatory, as distinguished from an interrupted or pulsatory current is concerned, there would be no difference whatever. The only difference would be that where the apparatus shown in figure 7 of the Bell patent was used a more complex or irregular undulatory current might be produced than with the arrangement shown in the Varley patent."
>
> Mol. Rec., pp. 354-355; O., pp. 751-752.

Prof. C. F. Brackett, testifying on behalf of the appellants in this case (Mol. Rec., p. 362; O., p. 759), states that the Varley Patent 1044 describes an undulatory current together with the means of producing it, and that there is no difference between the undulatory current of the Varley patent and that referred to in Mr. Bell's patent number 174,465.

Prof. Charles A. Young, another expert witness, called on behalf of the appellants (Mol. Rec., p. 400; O., p. 797), among other things testified as follows: " The magnetic inertia of this (induction coil) core is so great that there will never be an instant during which its magnetic condition will not be constant. A secondary coil is wound over the primary coil (as in an ordinary induction coil) and interposed in the circuit of the line. The consequence is a regular succession of electric waves of nearly sinusoidal form, alternately positive and negative, superposed upon the steady current of the line produced by the batteries in the line circuit." * * * Testifying further as to the identity of the currents, he said :

> " I think there is no substantial difference. In neither case is there any finite time during which the strength of the undulatory current is not increasing or decreasing. And the strength of the undulatory current at any given moment would be represented by approximately similar formulæ in both cases."

Moreover, there is no substantial difference between an undulatory current such as would be produced by the apparatus of Mr. Varley or by that shown in Figs. 5 and 6 of Bell's first patent, and an undulatory current created or generated by an apparatus constructed in accordance with Fig. 7 of said Bell patent. This fact is substantially admitted by Prof. Cross in his deposition (Dolbear Circuit Record, p. 528a), wherein he says :

> "So far as the electrical undulations are concerned, the form of apparatus shown in Fig. 7 is similar to that shown in Fig. 5, but *the mode by which motion is imparted* to the armature in Fig. 7 is entirely different from any of the modes intended to be used with the apparatus of Fig. 5," etc.

The exact and entire significance of this is that the undulations of current requisite to reproduce such sounds as Varley used differ from those requisite to reproduce the most complex tones of speech, is, like the difference in the sounds themselves, ONLY ONE OF DEGREE. The art of creating such undulations is one generic art; which in its specific branches demands no new principle, but only greater mechanical adaptation (see Cross, Mol. Case, 129, x-Int. 584–6, quoted, pp. 48, 49, 51, and N. J. McDonough Case, x-Int. 334–5).

In comparing the Varley patent with the method and apparatus shown and described in Mr. Bell's first patent it must also be borne in mind that Mr. Varley's condenser-receiver, like the magneto-receiver generally used by the appellees, is what Mr. Gray has termed a common or universal receiver—that is, a receiving instrument, which is not only capable of reproducing musical sounds, but is also capable of transforming electrical undulations into sonorous vibrations, and thereby produce articulate speech. As previously stated, Mr. Varley has suggested the use of the condensers themselves for *producing* sounds as well as for reproducing them. On that point, he says :

"The first or communicating station produces in its condenser rapid charges and discharges. These add to and take from the line a number of small electric impulses (that is, create electric undulations) without affecting the mean magnetizing power of the currents through the line; these impulses charge and discharge the second condenser at the other end."

The undulations in the first condenser are utilized to reproduce corresponding sounds in the condenser at the receiving station. Thus, it is seen that Mr. Varley

(1) Described and set forth in his patent a *common* or *universal receiver* capable of

(2) *Producing sounds of any kind*, which,

(3) Being transformed into electrical undulations, are

(4) Conveyed to a similar condenser or *universal receiver* at a distant station where they

(5) Produce corresponding sonorous vibrations and sounds.

V.

History of McDonough's Invention.

In the year 1867 at his home in Chicago Mr. James W. McDonough constructed an apparatus which is illustrated by the sketch found between pages 1266 and 1269, Mol. Rec., Defendant's Exhibits.

This apparatus was composed of a sound receiver and a rheotome (that is, a circuit interrupter), placed in the same voltaic circuit. The receiver consisted of a metallic hoop, or ring, over which was *stretched a membranous* diaphragm, near the centre of which was affixed a piece of inductive metal, so arranged as to be in close proximity to the poles of a horseshoe magnet, surrounded by a helix of insulated wire, one terminal of the helix being connected with a battery, the other terminal thereof being left free when the apparatus was not in use. The other pole of the battery was con-

nected by a wire to a file. By drawing the free or loose end of the wire over the serrations upon the file, the electric circuit was alternately made and broken, thus strengthening and weakening the attractive power of the magnet, causing it to attract and cease to attract the plate and diaphragm, thereby throwing them into vibration and producing sound. The pitch of the sound produced in the receiver varied with the rapidity of motion produced in the rheotome. The sound reproduced by this receiver was *continuous* (Mol. Rec., pp. 1265, 1266, 1269).

During the period intervening between the years 1867 and 1871 Mr. McDonough read descriptions of, and became familiar with the construction and operation of the phonautograph, an instrument adapted to the graphical representation of sounds. The phonautograph consists, essentially, of a conical tube across the smaller end of which a membrane is stretched to which is attached a light style consisting of a quill or bristle. The membrane being vibrated by air waves, produced by the human voice, or otherwise, causes the style thereto attached to trace a wavy line upon the surface of a blackened cylinder turned by a crank, the cylinder being so constructed and arranged that it travels endwise ; that is, in the direction of its axis, during the vibration of the diaphragm and its attached style.

McDonough had also read descriptions of the Reis telephone and was acquainted generally with the state of electrical and acoustical science at that time. While engaged in making some drawings for an electrical motor he conceived the idea of an instrument which would transmit and reproduce articulate sounds. The plan conceived by him included the use of a diaphragm or membrane at the transmitting and receiving stations (Mol. Rec., Defendant's Exhibits, p. 1271).

On the 20th day of August, 1871, Mr. McDonough made a drawing in his memorandum book, a *fac-simile*

of which is shown between pages 1270 and 1271, Mol. Rec., Defendant's Exhibits.

This drawing was inscribed by McDonough with the legend, "*August 26th, 1871. To send speech through wires by means of electricity.*"

The drawing followed Mr. McDonough's conception of a speaking telephone. It shows and illustrates a sound-receiving apparatus substantially like that made by him in 1867, which has already been described. This receiver is connected in a voltaic circuit with a sound-transmitting instrument consisting of a *membranous* diaphragm *stretched* over a hoop. To the centre of the diaphragm a small piece of metal is attached, and in contact therewith is a small metal pin supported by a suitable frame. The plate affixed to the transmitter diaphragm is connected by a wire with the receiver magnet and to one pole of a battery, the other pole of the battery being connected to the receiver magnet. Other plans of transmitters are shown in the sketch, one of them being like that illustrated in the drawing and described in the specification of Mr. McDonough's application for Letters Patent filed in the United States Patent Office on the 10th day of April, 1876.

Any electrician who was familiar with the descriptions of the Reis apparatus would have readily understood the intended construction sketched in the McDonough drawing of 1871 (Mol. Rec., Defendant's Exhibits, pp. 1270, 1271).

In April, 1874, Mr. McDonough showed this drawing to one F. L. Eastman and stated to him that he thought it was possible to send speech over a wire, and other conversation then took place concerning it. The same sketch was again shown to Eastman in April, 1875, and McDonough described it as an apparatus for transmitting speech (Mol. Rec., Defendant's Exhibits, pp. 1300, 1301, 1302).

In April, 1874, Mr. McDonough commenced the construction of his apparatus for the electrical transmis-

sion of articulate speech; he got his batteries into shape, and had a magnet constructed of wrought iron, to the centre or base of which a screw was soldered for the purposes of fastening the magnet to a frame. His work was, however stopped in consequence of ill-health and he was obliged to go Europe. He did not return from Europe until the latter part of November, 1874, and did not resume work upon his telephone until April, 1875 (Mol. Rec., Defendant's Exhibits, p. 1274).

In *May*, 1875, Mr. McDonough constructed the apparatus shown and illustrated between pages 1278 and 1285, Mol. Rec., Defendant's Exhibits, and he tested the same with the aid of Mr. F. L. Eastman. The receiving apparatus consisted of a tin case, cylindrical in form, over one end of which a *parchment diaphragm* was *stretched* and secured. Near the centre of the diaphragm a metallic plate was fastened. A horse-shoe magnet was mounted upon the frame of the instrument, its poles being opposite and near to the plate. Each leg of the magnet was surrounded by a helix of insulated wire, the terminals thereof being connected to binding screws upon the frame of the instrument.

The transmitting instrument consisted of a case, in form and material similar to that of the receiver, one end of the case being covered with a *stretched* parchment diaphragm. Upon the centre of the diaphragm a small piece of German silver was fastened, connected by a wire to a binding screw upon an arm mounted upon the frame of the instrument. Upon the metal plate affixed to the diaphragm rested the end of a needle which passed through a glass tube supported by the arm. The needle was free to move up and down in the glass tube, and was also connected to another binding screw by a thread of tin foil. The transmitting and receiving instruments were properly connected in a voltaic circuit (Mol. Rec., Defendant's Exhibits, pp. 1275–6).

It must be noted that the magnet and diaphragm of

the receiver employed in this apparatus were substantially like those employed by Mr. McDonough in his experiment of 1867, and the receiver was like that shown in the sketch of August 26, 1871. This apparatus was tested by Mr. McDonough, and he states in his deposition (Mol. Rec., Defendant's Exhibits' p. 1285) that "we could recognize tunes, but no words."

About June 1, 1875, McDonough made some slight changes in the transmitting apparatus last above described, but made no change in the receiver. The modified form of transmitter is shown in McDonough Drawing No. 3, pp. 1278, 1285, Mol Rec. He again tested the apparatus. Speaking of the result he says: "We could hear with this instrument perfect tunes, and could distinguish the tones of the voice, but I do not remember hearing any distinct words" (Mol. Rec., Defendant's Exhibits, pp. 1276, 1277).

Subsequently, and in the month of June, 1875, Mr. McDonough constructed a telephonic apparatus, illustrated in "McDonough Drawing No. 4," which is opposite page 1290 in the Mol. Rec., Defendant's Exhibits. The apparatus shown in thisdrawing is in all its parts substantially like that illustrated and set forth in the drawing of McDonough's application, filed in the United States Patent Office on the 10th day of April, 1876.

The receiving instrument shown in the drawing of this apparatus is in construction and mode of operation substantially like the receivers already described. The transmitter consisted essentially, of a parchment diaphragm *stretched* over a metal hoop. Upon the centre of the diaphragm two thin pieces of German silver were affixed about an inch and a half apart. A thin piece of German silver, arch-shaped in form, rested lightly upon the plates fastened to the diaphragm, and to such plates small wires were attached.

When this transmitter was first used, the arch-piece simply rested upon the plates or contact pieces of the diaphragm by the force of gravity. In practice it was

found that the arch-piece was liable to get out of contact with the diaphragm plates, and to overcome this difficulty the arch-shaped piece was at first secured in place by a thread passed through a hole in it, and thence through the diaphragm, and tied. Afterwards a little post or threaded bolt of brass, like that shown in McDonough's application for Letters Patent, was substituted for the string. The post or bolt passed through the diaphragm and the arch-shaped piece, and was secured at its upper end by an *adjusting nut* (Mol. Rec., Defendant's Exhibit, pp. 1286, 1287, 1288.).

McDonough substituted the brass post and nut for the thread was because he *could not regulate the instrument fine enough with the string, and so he replaced it with the nut and bolt* (Mol. Rec., Defendant's Exhibit, p. 1304).

When the string was used to secure the arch-shaped piece of metal in place, Mr. McDonough says:

"We could distinguish tunes and some words distinctly" (Mol. Rec., Defendant's Exhibit, p. 1288).

The results obtained after the little brass post was substituted for the string are stated by Mr. McDonough to have been as follows:

"*Clearly recognizable tunes and entire sentences of clearly understood words were transmitted through the instruments and heard at the receiver.*" * * * "*To my own knowledge the instruments tunes were 'Swanee River,' 'Muffin Man,' 'Shoo Fly,' and some others. The words which impressed themselves upon me more particularly were, 'Way down upon the Swanee Ribber, far, far away,' 'which I heard consecutively and clearly, noticing the elision at the beginning of the word 'way,' and the change of v to b in the 'river.' The words of other tunes were distinct when the instruments were properly regulated*" (*Mole. Rec. Defendant's Exhibit, pp.* 1288, 1289, 1290).

Concerning the results obtained with these instruments, Mr. F. L. Eastman testifies as follows:

"By experiments with this new machine we are able to recog-

nize the voice of the person singing, the tune that was sung, and many of the words of the tune; *also, you could understand words that were spoken and could recognize the voice of the person speaking* * * * I guess we exhausted all the songs we ever heard. I can give you the names of a few of them; others I do not remember. They were, 'Swanee River,' 'Down in a Coal Mine,' 'Old Zip Coon,' and others that I have forgotten. I heard many of the words of these songs, exactly which words, I cannot remember. I also heard Mr. McDonough say 'Hello Frank,' and other words that I cannot remember now" (Mol. Rec., Defendant's Exhibits, p. 1305).

Mr. McDonough fixes positively the date of these last experiments as being *in the last week of June, 1875* (Mol. Rec., Defendant's Exhibits, pp. 1288, 1289).

Mr. Eastman says that these experiments were made *previous to the 26th day of June, 1875*. He testifies as follows:

"On the 26th day of June, 1875, I left Chicago to visit my father and mother in Michigan, and told them of Mr. McDonough's experiments with this machine and the results obtained. *While at the breakfast table, I said, 'Now, if we only had Mac's machine rigged up, we could ask them what they were having for breakfast in Chicago'*" (Mol. Rec., Defendant's Exhibits, p. 1306).

About the 1st of September, 1875, Mr. McDonough resumed his work upon his telephonic apparatus for the purpose of obtaining *louder* articulation, and during the fall of that year he made fifteen different instruments, varying in size and in various other particulars. Mr. McDonough's account of the instruments made by him in the fall of 1875, is as follows:

"When I arrived at home I commenced work about the first of September, 1875, on new instruments for the purpose of increasing the volume of sound. I made probably fifteen different instruments, not differing in principle from that of the last of June, 1875. *I had diaphragms varying from one and one-half inches to fifteen inches in diameter. I used larger and smaller sized magnets*, and from one to eight cells of battery. I substituted other kinds of metal for the German silver in the transmitter; for the receiver diaphragm was substituted a wooden box of light wood to which the tinned iron was pasted. I had a receiver in which *the diaphragm was the end of*

a tin case which I had made. Not having obtained anything which gave a *louder* articulation, and being urged by those around me, I made application at the time stated" (Mol. Rec., Defendant's Exhibit, pp. 1294, 1295).

A fuller account of these instruments and Mr. McDonough's experiments with them, and with other instruments not specifically mentioned in his former deposition, to which we have alluded, will be found in the Overland Circuit Record, Defendant's Proofs, Vol. I., pp. 643–661. In the fall and winter of 1875 and 1876, Mr. McDonough constructed a large number of instruments, and among others those known as "McDonough Metallic Diaphragm Transmitter, October, 1875," photographs of which were produced, offered and received in evidence (Overland Circuit Record, Defendant's Proofs, pp. 647, 648); "McDonough Tin Drum Pendulum Transmitter, October, 1875," and "McDonough Tin Drum Receiver, October, 1875" (same record, p. 650); also "McDonough Brass Drum Transmitter and Receiver, October, 1875" (same record, p. 653). An inspection of these exhibits and of the photographs thereof introduced in evidence (Overland Circuit Record, Vol. I., pp. 648, 650, 653, 655), together with the description, operation and use of these instruments, as stated by Mr. McDonough in his deposition in the Overland Case, shows that he followed up the development of his telephone with great industry and ingenuity during the interval from June, 1875, down to the date of his application (April 10th, 1876) for Letters Patent.

Among McDonough's new instruments, produced and put in evidence in the Overland case, was the "McDonough Metallic Diaphragm Transmitter of October, 1875." This instrument was really made in September, 1875. It was mounted on a stand, and the body consisted of a brass cylinder having a *metallic* diaphragm of German silver, clamped to the cylinder by a brass ring. The instrument was

fastened to a wooden board by a metallic extension. In front of the diaphragm was a brass insulated post containing an adjustable screw. The screw was provided with a hole in its end, in which an electrode could be inserted so as to be in contact with the *metallic* diaphragm of the transmitter. Shortly after the instrument was made a screw was added for the purpose of regulating the contact between the diaphragm and the electrode inserted in the socket of the adjusting screw. Mr. McDonough used platinum, iron, German silver, brass and copper, and the point of an ordinary lead pencil (carbon) as electrodes. This instrument was operated by Mr. McDonough with receivers constructed in June and September, 1875. Speaking of the results obtained with the "Metallic Diaphragm Transmitter" joined in an electric circuit with the receivers above mentioned, Mr. McDonough says:

> "We obtained very good articulation from it. We used it as a speaking transmitter in connection with wires that I had up in the house, and we used it with very good results—*very good speech rather.*"

It will also be noted that Mr. McDonough used *carbon* as an electrode in this instrument in 1875 (Overland Circuit Record, Defendant's Proofs, Vol. I., pp. 646–648).

The "Tin Drum Pendulum Transmitter and Receiver" are described on pages 648, 649, 650 of the same record. Their construction and mode of operation will be readily understood.

Concerning the results obtained with these instruments (at page 649 of the same record,) Mr. McDonough says: "From the experiments with these receivers we obtained *some very good articulate speech*, but the resonance of the drums was very great, and interfered to some extent with articulation."

McDonough also constructed and used a "Brass

Drum Transmitter," which is described on pages 650–653, Overland Circuit Record. This instrument was provided with means for adjusting the electrodes employed in it, and also contained devices for adjusting the magnet relatively to the metal plate attached to the diaphragm (Overland Circuit Record, Vol. I.; Defendant's Proofs, p. 654).

Thus it will be seen that the instruments constructed by Mr. McDonough and used by him *in the year 1875, for the transmission, and reproduction of articulate speech, contained all the vital and essential elements of the telephonic apparatus now in commercial use* (Prof. Brackett, Mol. Rec., Vol. I., pp. 435–437; Prof. Young, same record, pp. 388–391).

On the 10th day of April, 1876, McDonough filed an application for Letters Patent in the United States Patent Office, which will be found in the Mol. Rec.; Defendant's Exhibits, pp. 1254–1258.

In this application McDonough declared that he had invented

> "a means for transmitting articulate sounds from one place to another through the medium of electricity," and applied to the invention the term 'Teleloge,'"

a term theretofore unknown in the art of electricity, but which is accurately descriptive of the instrument that he invented. Referring to the transmitting and receiving membrane of his apparatus, McDonough declares in his application that they are to be

> "so constructed as to vibrate in accord with the vibrations of articulate sounds;"

and that they are to be so arranged with reference to other parts

> "that the vibrations of the transmitting membrane or apparatus, produced by articulate sounds, are transmitted by the electrical current to the receiving membrane or apparatus, and so to cause a

like vibration of the receiving membrane or apparatus, and so as to cause it to reproduce the articulate sounds transmitted from and by the transmitting membrane or apparatus."

Furthermore, after describing the construction of his apparatus, he thus refers to its operation.

"The transmitting membrane A, being sensitive to the vibration of articulate sounds produced thereon, is caused to vibrate in sympathy therewith;"

and again, referring to the alternate magnetization and de-magnetization of the receiving magnet produced by the current flowing over the line and attracting the armature of the receiver he declares that it

"causes it (armature) and the receiving membrane F, to vibrate simultaneously with the vibrations of the transmitting membrane A, and in accord therewith, and so that the said membrane F reproduces the articulate sound transmitted from and by the membrane A."

Manifestly McDonough could not have employed more explicit language to express the idea that he had invented an electric speaking telephone. He stated what he conceived to be the fundamental principle upon which it operated, viz: That the transmitting diaphragm should "*vibrate in accord with the vibrations of articulate sound*" and that the electrical variations created thereby should cause the receiving membrane to "vibrate simultaneously with the vibrations of the transmitting membrane and in accord therewith," so that the articulate sound spoken to the transmitter would be reproduced by the receiver. In this connection it will be noted that Mr. McDonough clearly set forth in his application that he had invented *a telephonic apparatus* or "*a means for transmitting articulate sounds from one place to another through the medium of electricity.*"

Now, from the foregoing history of McDonough's researches and work in the art of telephony we find:

1. That in 1867 he made and experimented with a telephonic receiver consisting of the combination, in an electric circuit, of a magnet and a diaphragm arranged in close proximity thereto.

2. That in 1871 he made a drawing of such receiving instrument combined in an electric circuit with three different forms of transmitters, and inscribed upon the drawing the legend: "*To send speech through wires by means of electricity.*"

3. That in April, 1874, he exhibited and explained this drawing to a friend, and commenced the construction of the apparatus, but its completion was deferred by illness.

4. That early in 1875 he renewed his researches and work, and in *May* of that year completed an apparatus by which *tunes* could be transmitted and reproduced.

5. That in *June, 1875, he completed a set of instruments*, substantially like that shown and described in his application for Letters Patent, and *at that time was able to transmit and reproduce therewith "clearly recognizable tunes and entire sentences of clearly understood words.*"

6. That in the fall of 1875, Mr. McDonough made fifteen different instruments, some of them containing *metallic* diaphragms and *adjustable* electrodes, and in one of which he employed a *carbon* electrode in combination with a *metallic* diaphragm. With these instruments articulate speech was transmitted and reproduced. His purpose in making so many instruments was to obtain greater *loudness* in the reproduced sounds. He felt that for *commercial* use it was desirable that the instrument should be capable of producing *louder* tones.

One of the principal reasons why the so-called magneto-telephone of Mr. Bell is not generally employed as a sending or transmitting instrument is, that its tones are *too feeble* for extended practical use.

7. That on the 10th day of April, 1876, before Mr.

Bell had disclosed to the world that he had invented a speaking telephone, McDonough set forth in his application for Letters Patent, that he had invented "*a means for transmitting articulate sounds from one place to another through the medium of electricity.*"

8. That while Mr. Bell met with failure on the trial of his first pair of instruments, in July, 1875, and appears to have made no further attempt *to transmit speech or to make a telephone*, until after his patent was granted, (March 7, 1876)—McDonough, on the other hand, having conceived his invention as early as April, 1875, made two different sets of instruments, and, *before the 26th of June, 1875, therewith electrically transmitted*, "*clearly recognizable tunes and entire sentences of clearly understood words.*"

9. That prior to Bell, McDonough constructed an *apparatus capable of transmitting and reproducing articulate speech*, and set forth in his application for Letters Patent, that that was the object of his invention. He had thus *completed* his invention in the eye of the law, because his apparatus was of *some* practical utility. It was not necessary that his invention should have been made as good as it possibly could be as a practical machine. It was sufficient that his apparatus was of some practical utility.

In Railway Company vs. Sayles, 97 U. S., 554, referring to the prior use "The Springfield Car Brake," the Court said:

> "It was undoubtedly attended with some inconvenience in its operation, especially in going around sharp curves. But this did not prevent it from being used; and on a straight track, or on a track having only slight curves, it operated very satisfactorily."

In Coffin vs. Ogden, 18 Wall., 120, it is held that prior knowledge and use by a single person is sufficient.

But it is asserted by the appellees in this case, that McDonough's apparatus was inoperative and worthless

as a speaking telephone, because it was incapable of transmitting and reproducing articulate speech. This proposition is sought to be maintained on the ground that McDonough in his application for Letters Patent described one element or device (arch-shaped piece) in his transmitter as "the circuit breaker," operating to make and break the circuit at each vibration of the diaphragm. It is contended that such action (interruption of the circuit) is fatal to the electric transmission of speech.

Now in disproof of this *theory* of the appellee's counsel that McDonough's apparatus was inoperative and therefore did not transmit and reproduce speech, we note:

FIRST. The *fact* that the capacity of the instrument made by McDonough in June, 1875, is proven by the evidence of several witnesses which stands uncontradicted. As to the *May* instruments, it is stated by the witnesses that *tunes* were transmitted and distinctly heard. With the improved instruments of *June*, 1875, the witnesses testify that they not only heard *tunes, but distinctly recognized the words of the tunes, and also* "*entire sentences of clearly understood words.*" No suspicion is cast upon the veracity of any of these witnesses and they are therefore entitled to full credit. Their testimony cannot be overthrown by a *theory* based upon pure assumption. The question here to be determined is whether as matter of *fact*, McDonough's apparatus transmitted and reproduced words and sentences as stated by these unimpeached witnesses. Either they heard what they testified to or they must be held to have committed perjury. We submit that no Court ought to disregard their evidence in the circumstances of this case.

SECOND. Professors Young and Brackett, two eminent physicists, have experimented with instruments made substantially like the apparatus shown and de-

scribed in McDonough's application, and also with other instruments like those which have been referred to as being made by Mr. McDonough prior to his application.

Professor Young, after describing the construction and mode of operation of a McDonough Transmitter and Receiver, (Mol. Rec., pp. 388–91) testified concerning the capacity of those instruments to transmit and reproduce speech as follows:

"I have experimented with such apparatus and have been able to carry on conversation. My experiments were made in the physical laboratory of the College of New Jersey, in connection with my colleague, Prof. Brackett. Our first experiments were made November 21, 1883. We transmitted and reported to each other many words and several complete sentences. On November 30 we resumed the experiments and obtained still better satisfaction. We experimented again on the evening of December 1st, with the same apparatus, *and upon this occasion we obtained the finest transmission of articulate speech which I have ever heard. The clearness and beauty of tone was very remarkable.* Professor Brackett repeated several stanzas of poetry, which I heard perfectly. And I afterwards exchanged places with him with similar results. I have also used the McDonough receiver in connection with the Reis transmitter, as stated in answer to a previous question."

Prof. Cyrus F. Brackett, being interrogated as to whether he had ever tried a McDonough apparatus like that shown in the application of April 10th, 1876, (same Record, p. 437) testified as follows:

"I have experimented with apparatus constructed in close accordance with the drawings alluded to, and have been able to carry on intelligent conversation.

"In the Physical Laboratory of the College of New Jersey, November 21st, 1883, in connection with my colleague, Professor Young, I experimented with the McDonough transmitter and receiver, joined up by a line wire and employing in the circuit, common gravity battery. We clearly and unmistakably transmitted and reported many words, and also several complete sentences.

"On November 30th we resumed the course of experiments, and with complete satisfaction. Among other sentences which were transmitted, I noted at the time 'Mary had a little lamb, its

fleece was white as ink.' Other equally unexpected statements were made and correctly transmitted, and reported both by Prof. Young and myself. The instruments were then laid aside until the evening of December 1st. We had in the circuit besides the McDonough instrument two common magneto-receivers, one at either station, of the common 'butter-stamp' form. After a little delay in adjustment, I retired to the room containing the receiver and heard, with wonderful clearness, 'Old Mother Hubbard went to the cupboard,' &c. I then called to Prof. Young through the magneto-telephone, and requested him to change places with me. This done, I repeated four stanzas of the doggerel: 'Why, Phœbe, are you come so soon; where are your berries, child,' &c., and ten or twelve lines of Cary's 'Power of Eloquence,' beginning, 'Heard he those loud contending waves,' &c. He then requested me to sing. I did so, and musical tones were reported as being heard satisfactorily. I have also used the McDonough receiver in connection with the Reis transmitter, as also set forth in a former interrogatory."

THIRD. The use by McDonough of the term "circuit breaker," as applied to the arch-shaped electrode, and the corresponding language in his specification descriptive of its supposed action is at most the embodiment of a mere *theory* on his part, and is pure surplusage and negligable.

McDonough may have been ignorant or uncertain of the scientific principle embodied in his invention, or he may have been confident as to what it was, and others may then have thought, or may now think differently. It matters not whether his *theory* was correct or erroneous; if he gave such a description of the apparatus invented by him with such practical suggestions as to its use as were required to enable a person skilled in the art to practise the invention; he complied with the statute.

Moreover, the theory advanced by the appellees that it is impossible to transmit and reproduce articulate speech with a microphone transmitter, if the vibrations of the diaphragm produce breaks of contact between the electrodes of the instrument, has no good scientific foundation. On this subject we beg leave to call the

attention of the Court to the depositions of Professors Brackett and Young.

Professor Brackett, Mol. Rec., pp. 488, 489, 490.

Professor Young, Mol. Rec., pp. 409, 410; Overland Record, Vol. I., Defendant's Proofs, pp. 595, 596.

The question here at issue is not how McDonough may have thought his apparatus operated at the time he filed his application for Letters Patent, but whether as a matter of *fact* he constructed and used apparatus *prior to July, 1875*, by which he transmitted and reproduced articulate speech. If he did that, then it is of no consequence what his *theory* may have been as to the continuity or discontinuity of the circuit. In concluding this part of our argument we repeat that McDonough has proven that he transmitted and reproduced speech in June, 1875, and his application filed in the United States Patent Office on the 10th of April, 1876, tends strongly to corroborate that fact, in that it is therein stated that the object of his "invention is to provide ameans for transmitting articulate sounds from one place to another through the medium of electricity."

VI.

Gray's Telegraphic and Telephonic Inventions.

Elisha Gray, after completing his college course, entered upon his career as a professional electrician and inventor in the year 1865.

In the winter of 1866 and 1867, he constructed an instrument for transmitting tones and called it a "Musical Telegraph."

The apparatus then used consisted of a vibrating electrotome, or reed, placed in the primary circuit of an induction coil, an electro-magnet having a polarized armature and a Morse Key in the secondary circuit. Whenever the key was depressed, the note given by the electrotome was heard in the receiving magnet.

At this time, Gray conceived the idea of constructing an instrument for transmitting tunes similar in plan to those made by him at a later date.

From 1867 until about the beginning of the year 1874, he was constantly engaged in inventing, devising and constructing electrical and telegraphic apparatus.

About May, 1872, the "Western Electric Manufacturing Company" of Chicago, was organized for the manufacture of all kinds of electrical and telegraphic instruments, and thereupon Mr. Gray became the superintendent of that company, which position he held for several years.

Since 1874 a large number of American and Foreign patents have been granted to Mr. Gray for various improvements relating to harmonic telegraphy and telephony.

Mr. Gray was both theoretically and practically conversant with the sciences of electricity and magnetism, and was also conversant with the science of acoustics when he began his researches in multiple telegraphy and telephony.

While engaged in studying the phenomena of induced currents, Mr. Gray noticed a sound proceeding from the electro-magnet connected in the secondary circuit of a small Rumkorff coil, which was at that time in operation. This phenomenon had previously been observed by Page, Henry and others, but it served to direct Mr. Gray's mind to the subject of transmitting tones telegraphically.

In the winter of 1873 and 1874 his attention was called to the curious fact that on connecting one of the secondary terminals of an induction coil with the me-

tallic lining of a bath-tub, the other terminal being held in the hand, a musical note given by the vibrating electrotome issued from the metallic surface whenever the hand was moved over it.

This observation subsequently led to the construction of what is known as "Gray's Animal Tissue Receiver," with which and an electro-magnet tone receiver he experimented extensively. Subsequently he substituted for the "Animal Tissue Receiver" an "Electro-magnet Receiver," consisting of an electro-magnet combined with a hollow box of tinned iron having an opening in one side, while the opposite side was held over the poles of the magnet at such distance from it, as would produce the best effect. With this apparatus Gray noticed that when he depressed two finger keys on his transmitter, if these were in proper relation to each other, a composite tone would be received, thus demonstrating the fact that with a receiver properly constructed and a transmitter suitably made and arranged in an electric circuit composite tones of varying quality could be transmitted and received telegraphically.

This apparatus is shown and described in British Letters Patent No. 2646, dated July 29th, 1874.

Dowd Circuit Record, Vol. III., pp. 566–571; **O.**, 3659–3668.

That part of the apparatus shown and described in said Patent No. 2645 is also embraced in United States Letters Patent Nos. 166,095, of July 27th, 1875; Reissues Nos. 8558 and 8559, of January 28th, 1879.

Dowd Circuit Record, Vol. II., pp. 566–576, 578–648; **O.**, 3659–3674, 3676–3754.

The first of the above-mentioned patents is known as "Gray's Animal Tissue Patent," and those subsequently referred to are known as "Gray's Magnet Receiver Patents."

It will be observed that " Gray's Magnet Receiver Patents " only relate to, and embody the mechanism shown in Fig. 4 of the British Patent No. 2646, of July 29th, 1874.

The invention set forth in the " Animal Tissue Patent " relates to a method of producing musical tones of any desired pitch at any point, in an electrical circuit, and consists in transmitting *a series of impulses of induced electricity of high tension* (undulations), corresponding in number to the number of audible vibrations constituting said musical tones, through living tissue in contact with any resonant substance.

The apparatus which is intended to carry out that part of Mr. Gray's invention is shown in Fig. 3, of the British patent, and consists, essentially, of an induction coil, in the primary circuit of which a battery, two vibrating electro-tomes, and two telegraphic keys of the usual form are interposed. In the secondary circuit of the induction coil a person is placed, who brings his hand or any other part of his body in contact with any resonant substance, which is a conductor of electricity, so that the circuit is completed through it, the resonant substance being either a metallic cylinder like that shown in the patent, or a plate of metal stretched above the body of a violin by metallic strings, etc.

As already stated the " Magnet Receiver Patents " of Mr. Gray embody that part of the apparatus described in his " Animal Tissue Patent " shown in Fig. 4 thereof.

It is to that apparatus (fig. 4) that we desire to direct the attention of the Court, and it will be found most clearly set forth in the " Magnet Receiver Reissues."

Dowd Circuit Record, Vol. III., pp. 604–615. **O.**, 3705–3721.

The invention as set forth in those reissues relates to " Electro-Harmonic Telegraphy," and is based upon the fact that an electro-magnet elongates under the action of an electric current, and contracts again when the

current ceases. By such action a succession of impulses, or interruptions, causes the magnet to vibrate, and if the vibrations be of sufficient frequency a musical tone will be produced, the pitch of which depends upon the rapidity of the vibrations. The transmitting instrument is mounted upon a suitable frame or base. Upon the same frame an induction coil is placed, having the usual primary and secondary circuits.

Automatic vibrating electrotomes (two in number) of the usual construction have their vibrating circuit springs so adjusted, that when in action they produce musical tones, which from the difference in adjustment and the length and thickness of the springs, are of different pitch. A common telegraph key is also placed in the primary circuit to make or break the battery connections. The drawing shows two electrotomes of different pitch and two keys. Both keys and electrotomes are in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased so that *electrotomes extending through two or more octaves may be employed.* A receiving instrument consisting of an electro-magnet is placed in the secondary circuit of the coil. A hollow box, drum, cylinder, or resonator of metal is placed on or above the poles of the magnet. The resonator is composed of a circumferential band having two disks or diaphragms, one of which rests upon or near the magnets, constituting an armature therefor, and vibrating in unison therewith, while the other disk or diaphragm of the resonator is perforated with S-shaped openings. The receiver is what is called a " common receiver "—that is, one capable of responding to or reproducing *all kinds of tones*, both simple and composite.

In this apparatus *induced* currents are employed.

When a single electrotome is thrown into vibration its corresponding tone will be reproduced on the resonator by the magnet When electrotomes of different

pitch are successively operated, their tones will be correspondingly reproduced by the receiver or resonator; and when two or more electrotomes are simultaneously sounded, the tone of each will still be reproduced without confusion on the sounder or resonator, by which means *composite tones, melodies or tunes can be reproduced.*

By the method or system employed in this apparatus, audible tones are simultaneously reproduced upon the metal disk or diaphragm of the receiver through the intervention of an electro-magnet included in a *closed* electric circuit. Thus it will be observed that two or more series of rhythmical impulses or vibrations representing musical vibrations or sounds, or composite tones, may be simultaneously transmitted and reproduced.

The apparatus above described, which is shown in Fig. 4 of Gray's British Patent, *contains a common or universal receiver capable of responding to all kinds of tones, and consequently of reproducing articulate speech. This receiver is essentially a Magneto-Telephone.* It must be noted in this connection that the induced currents passing through the secondary circuit to the common or universal receiver are *undulatory* in character, and, therefore, substantially like the undulatory currents employed in the apparatus shown in Figs. 5 and 6 of Mr. Bell's first patent.

The transmitting instrument shown in Gray's English Patent of July 29th, 1874, is designated in the Dowd Record as "Gray's Two-Tone Transmitter."

Goodridge, Dowd Circuit Record, Vol. I., p. 69. **O.**, p. 2857.

A two-tone transmitter, like that illustrated in said English Patent, was made before May, 1874, and was publicly used about that time. Its tones being received

upon a receiver consisting of a thin metallic plate like that represented in Fig. 3 of said English Patent.

Goodridge, Dowd Circuit Record, Vol. II., pp. 69, 70. **O.**, 2857, 2858.
Gray, same record, p. 113. **O.**, 2900.

Gray's receiving instrument, consisting of an electro-magnet and resonator placed on or held near the poles thereof, was constructed and first used in the early part, or near the middle of the month of May, 1874, at the works of the Western Electric Manufacturing Company, at Chicago.

Goodridge, Dowd Circuit Record, Vol. I., pp. 74, 75. **O.**, 862, 2863.
Gray, Dowd Circuit Record, Vol. I., p. 114. **O.**, 2900½.

This receiver was afterwards frequently used in connection with other transmitting apparatus, as will hereafter be shown.

Other witnesses corroborate Mr. Goodridge as to the construction and use of Gray's two-tone transmitter.

Dowd Circuit Record, Vol. I., pp. 179–182. **O.**, 2964–2967.

He is also corroborated as to the construction and use of the magnet receiver.

Dowd Circuit Record, pp. 178, 181–185. **O.**, 2963, 2966–2970.

In the month of May, 1874, Mr. Gray constructed several forms of receivers, in addition to the "Animal Tissue Receiver" and the "Magnet Receiver" with a resonator placed on or near its poles. Among others, he constructed a magnet receiver, consisting of an iron pan mounted upon a wooden base, and supported by a standard firmly screwed to such base, and to the rim of the pan. The bottom of the pan formed a diaphragm for the reproduction of musical and other sounds. The rim of the pan answered as a frame, in

which the diaphragm was held in position. Upon another standard mounted upon the same base, and near to it, was fixed an electro-magnet whose poles projected into the pan, nearly, but not quite touching, its bottom. By means of a screw located between the two standards, the magnet could be adjusted relatively to the diaphragm or bottom of the pan. This receiver is shown in the Dowd Circuit Record, Vol. II., p. 766. **O.**, 3895.

The same instrument is also shown in "Gray's Concave Diaphragm Receiver, Speaking Telephone Application," Dowd Circuit Record, Vol. II., pp. 745-751, **O.**, 3870-3880.

The "concave diaphragm receiver," usually called "Gray's Tin Pan Receiver," was first used in July, 1874, with a single tone transmitter.

Dowd Circuit Record, Vol. I., pp. 71, 72, 76, 77 ; **O.**, 2859, 2860, 2864, 2865.

The first use of the instrument was at the works of the Western Electric Manufacturing Company in Chicago, but it was subsequently publicly used in connection with various kinds of transmitters and it is capable of reproducing composite tones and articulate speech. It is, in fact, a magneto telephone.

In May, 1874, Mr. Gray constructed a musical instrument for transmitting melodies. It embodied eight single-toned transmitters in one instrument. There was a key for each reed answering to the key of a cabinet organ.

Goodridge, Dowd Circuit Record, Vol. I., pp. 77, 78 ; **O.**, 2865, 2866.

Gray, Dowd Circuit Record, Vol. I., pp. 115, 116 ; **O.**, 2901½.

In the month of July, 1874, Mr. Gray made another instrument consisting of two octaves. The instrument constructed in May, 1874, had eight reeds representing the diatonic scale ; that constructed in July, 1874, was

substantially like the first, except that it had more reeds and keys.

Goodridge, Dowd Circuit Record, Vol. I., p. 78 ; **O.**, 2866.
Gray, Dowd Circuit Record, Vol. I., p. 115. **O.**, 2901.
Kellogg, Dowd Circuit Record, Vol. I., p. 179 ; **O.**, 2964.
Barton, Dowd Circuit Record, Vol. I,. p. 182 ; **O.**, 2967.

The two multiple-transmitters, single and double octave, were made by Mr. Gray for the transmission of tunes and melodies and they were combined and used in a closed electric circuit with the "magnet receiver" and with the "concave metallic diaphragm receiver." They were thus publicly used in the Cities of New York and Chicago prior to August, 1874.

Goodridge, Dowd Circuit Record, Vol. I., pp. 78, 79 ; **O.**, 2866, 2867.
Gray, Dowd Circuit Record, Vol. I., pp. 115, 116 ; **O.**, 2900½, 2901.
Kellogg, Dowd Circuit Record, Vol. I., pp. 179, 180 ; **O.**, 2964, 2965.
Barton, Dowd Circuit Record, Vol. I., pp. 180, 182 ; **O.**, 2965, 2967.
Stager, Dowd Circuit Record, Vol. I., pp. 184, 186 ; **O.**, 2969, 2971.

Testifying concerning the use of the "Two-octave Transmitter" with the "Concave Metallic Diaphragm Receiver" connected up in a closed electric circuit, Mr. Gray says (p. 116): "The results were satisfactory in every respect. A number of tunes were transmitted which could be heard and recognized in any part of the room without the least difficulty."

The single-octave transmitter, in connection with the magnet receiver, was also publicly used and exhibited in New York City in May, 1874, and also in Chicago and Washington.

Gray, Dowd Circuit Record, Vol. I., pp. 116–120 **O.**, 2901½-2905.

In these multiple transmitters each key was provided with a steel reed or electrotome, tuned to correspond to its position in the musical scale. One end of each reed was rigidly fixed, while the other was left free, and was actuated by a local battery. All the keys in the instruments, whether one or more octaves, had corresponding reeds and actuating magnets, the only difference being in the tuning of the reeds. Only one main and one local battery were used and the connections to each key were run in branch circuits from binding screws, properly arranged upon the instrument. But since the branches were opened at the key points, neither of the batteries was closed unless a key was depressed. If now the keys were manipulated a tune might be played which was audible to the player. When any key was depressed the local battery set in vibration its corresponding reed, which sounded its own fundamental note according to the law of acoustics. The instrument was, in fact, an electrical organ.

The motive power was electricity, and the main battery had no part whatever in its operation. When the transmitting apparatus was properly adjusted and the main circuit closed, a series of electric impulses, waves or undulations were sent through the line corresponding in number per second to the fundamental of the reeds.

It will be observed that these instruments transmitted a series of electrical waves or impulses to a common receiver, whereby they were transformed into composite tones.

In August, 1874, Mr. Gray went abroad, and while in London publicly exhibited and used his multiple transmitter, coupling it in an electric circuit with the "Concave Diaphragm Magnetic Receiver."

Goodridge, Dowd Circuit Record, Vol. I., pp. 81–84 ; **O.**, 2869–2872.
Gray, Dowd Circuit Record, Vol. I., pp. 120, 121 ; **O.**, 2905, 2906.

Thus in 1874 Mr. Gray demonstrated that composite

tones could be transmitted and received telegraphically, and thus logically he was led to the conception that articulate speech could be transmitted over a telegraph wire.

In December, 1874, Mr. Gray publicly announced in "The Journal of the American Electrical Society," Vol. I., p. 13, his discovery of the true method of transmitting composite vibrations.

It consists in causing the effective strength of the electric current by which the transmission is effected to rise and fall with the varying impulses of the vibrations or waves which are to be reproduced.

When this discovery was made the *general problem* of harmonic telegraphy and telephony was solved.

In September, 1875, Mr. Gray publicly operated and used an apparatus composed of a multiple transmitter capable of sending a number of tones simultaneously, each of the volume of one tone sounded separately, and connected such multiple transmitter with a receiving bar of metal opposite the poles of the magnet, *in a constantly closed circuit with the magnet constantly charged.*

Goodridge, Dowd Circuit Record, Vol. I., pp. 90, 269, 270, 271, 272; **O.**, 2878, 3054, 3055, 3056, 3057.

The method of connecting the instruments in circuit with the main battery, during their use in New York City is shown in the drawings of the patents granted to Mr. Gray, known as No. 175,971, dated April 11th, 1876; No. 186,340, dated January 17th, 1877, and No. 205,378, dated June 25th, 1878.

In this connection we may properly refer to said patents.

Patent 175,971 relates to harmonic telegraphs of the class shown and described in letters patent 166,095, and 166,096 granted to Mr. Gray (Dowd Circuit Record, Vol. II., pp. 578–583, 615–621) and in an applica-

tion for letters patent filed by Gray, Feb. 23d, 1875. The object of the invention is to dispense with local batteries and sounders and all adjustments at the receiving end of the line, which is attained by means of an apparatus which analyzes composite tones transmitted electrically through a wire, whereby the operator is enabled to read directly from the tone transmitted. The receiving instrument consists of a resonant box such as is used for intensifying the sound of a tuning fork. A suitable support secured upon the box sustains an electro-magnet of ordinary construction. Upon the support sustained by the magnet a vibrating tongue or reed is fastened and is united with one pole of the magnet. The free end of the reed passes close to, but does not touch the other pole of the magnet.

Letters Patent 186,340 relate to an "electro-harmonic" system of multiple telegraphy, in which composite tones are transmitted through a single wire and analyzed or separated at the receiving end of the line by vibrating reeds, bars, or strings, tuned correspondingly with the respective transmitters of the composite tones.

The improvement is designed to insure the transmission of tones of uniform amplitude of wave whether a greater or less number of tones be transmitted simultaneously, which end is attained by combining each transmitter with its respective section of the main battery by a short, or shunt, circuit in such manner that each section is utilized for the transmission of the vibrations of its own tone, without interfering or drawing upon the other section of the battery, or opening the main circuit, and when not transmitting, the unemployed sections of the battery flow steadily to line, without affecting the working transmitters of the other sections.

The improvement possesses two distinguishing characteristics:

FIRST. That of a main circuit *always closed.*

SECOND. The passage through this circuit of a smooth current, so to speak, when all the transmitters are act-

ing, each transmitter when in operation throwing its respective portion of said current into vibration, so that there may be a smooth current, and *one or more vibratory waves simultaneously transmitted through the circuit, or the entire current may be thrown into vibration.*

Three transmitters with their batteries and corresponding receivers at each end of the line are so arranged as to transmit three messages each way simultaneously; but a greater or less number of transmitters and receivers may be employed, and may be so arranged as all to transmit one way instead of in opposite directions.

Each battery is connected with its respective transmitter by a short circuit or shunt wire. The arrangement of circuits is set forth in the patent and is similar to an ordinary Morse circuit *closed, and without a key or means of making or breaking the circuit.*

The drawings represent six sets of transmitters, each set being composed of a common open circuit, a Morse telegraphic key and a musical transmitter. These transmitters are all alike in construction, but each one is tuned to a different pitch and has a receiver correspondingly tuned at the other end of the line.

After describing the arrangement and adjustment of the apparatus, the specification of the patents says:

"Now, if the reed or bar of transmitter A be vibrated by its local battery (which is omitted from the drawing to avoid complication, but the operation of which is well understood) and the key belonging to it and in the same circuit with it be depressed, the shunt circuit around section 1 will be completed every time the vibrating bar or reed makes contact with its break-point, thus producing a set of *waves* or *electrical vibrations throughout the line*, the *waves* succeeding each other at the rate per second corresponding to the vibrations of the transmitting reed or bar, which *waves will induce corresponding impulses* in all the magnets of a power approximating one-sixth of the whole battery."

Again, the specification states that "It will be observed that by working with this improved system *the main circuit is never opened, owing to which fact the*

integrity of each set of waves is preserved, thus rendering analyses easy at the receiving end of the line. The first claim of the patent is as follows:

"The improvement in the art of telegraphically transmitting composite tones, hereinbefore set forth, which consists in working a *closed circuit with a continuous current from a main battery*, portions of the whole of which current are thrown into vibration at will by the transmitters.

This patent number 186,340 is known as "Gray's Closed Circuit Patent" and the invention therein set forth was published in the "Journal of the American Electrical Society" in December, 1874. It was also patented in Great Britain May 4, 1876.

Patent No. 205,378, June 25th, 1878, refers to improvements in the art of generating and transmitting through an electric circuit rhythmical impulses, or *undulations, vibrations or waves representing composite tones, musical impressions or sounds of any kind, character or quality whatever, and of audibly reproducing such vibrations. It also describes apparatus for generating and reproducing such impulses, undulations, vibrations or waves.*

The specifications of the patent, after referring to sundry previous patents granted to Mr. Gray, then sets forth the invention as follows:

"My present invention constitutes an improvement set forth in the patents and applications above recited, and contemplates the combination in an apparatus for generating and transmitting vibrations, impulses or waves representing composite tones, of a closed circuit, a series of transmitters vibrating at such relative speeds as to produce the fundamentals and harmonics of the tone to be transmitted, a main battery so arranged as to give each transmitter the desired relative amplitude of vibrations, and a common receiver or one capable of reproducing tones of every variety and quality."

It will be observed that this patent No. 175,971 also shows a *closed* circuit like patent No. 186,346, which shows a closed circuit in which the current from the main battery keeps the receiving magnet constantly

charged, *a device for varying the power of the electro-motive force of the current by superposing thereupon the vibrations or undulations generated by the transmitters.*

The apparatus shown and described in this patent employs a closed circuit and undulatory current.

Renwick, Dowd Circuit Record, Vol. I., pp. 206, 207, 208, 209 ; **O.**, 2991, 2992, 2993, 2994.

We have already noted the fact that Mr. Gray's multiple transmitters were used in a *closed* circuit substantially like that set forth in the closed circuit patent No. 186,340.

Goodridge, Dowd Circuit Record, Vol. I., pp. 269–273 ; **O.**, 3054, 3058.

A public exhibition of Gray's multiple transmitters with various receivers is described by Mr. Frank L. Pope, an eminent electrical engineer (Dowd Circuit Record, Vol. I., pp. 328, 329), as follows :

"Int. 15. Will you describe all that you saw done in New York in the autumn of 1875 in the way of the multiple transmission of sound by means of the apparatus referred to in Mr. Goodridge's answer, including the receiver used?

"Ans. I saw the apparatus operated in three different ways, which I distinctly remember. In the first instance a series of reeds, I think four in number, was connected with Morse keys, local batteries and sections of main battery, in the manner deseribed by Mr. Goodridge in his said first answer, page 271 of the printed record, beginning at the words 'in the use referred to,' and ending with the end of the answer. Four receiving instruments were arranged consecutively upon the main line at the receiving station, which was in another room of the same building. These receiving instruments each consisted of an electro-magnet, the armature of which consisted of a tuned ribbon of iron or steel, each one being tuned in unison with one of the transmitters. Each pair of instruments, consisting of a transmitter and its receiver, was tuned to a rate of vibration differing from any of the others. To each receiver was attached a local circuit contact point, the precise construction of which I do not recollect, but which was so arranged as to cause or permit the armature of a common Morse sounder in the local circuit to be attracted whenever the ribbon was thrown into

vibration. With this arrangement, four transmitting operators could and did simultaneously send four distinct communications to four receiving operators over one wire without confusion. After experimenting in this way within the building, *a trial was made between Boston and New York, the transmitters being in Boston and the receivers in New York. This experiment was entirely satisfactory and successful.* I actually participated in the experiment as one of the receiving operators. The next experiment was made with the same transmitters arranged in the same manner as before, but a *common receiver* was used for the four sets of signals. This was placed in the centre of a square table, and four operators, one of whom was myself, were ranged around the table. Each separate communication was heard in the form of a *continuous tone* broken up into different lengths corresponding to the dots and dashes of the telegraphic alphabet. Each operator listened to the particular tone representing his own message, paying no attention to the others. Although frequently all four of the tones were heard simultaneously, yet I recollect that we experienced little or no difficulty in distinguishing the different tones from each other, and in reading and copying the communications therefrom. I do not recollect whether this experiment was tried with the transmitters in Boston or in another room in the same building.

"The third experiment consisted in the transmission of tunes by means of a keyboard of two octaves arranged upon precisely the same principle, both as regards the construction of the transmitters and their connection with the main and local batteries and the main circuit, as those in the former experiment. The receiver used in this experiment consisted of a hollow wooden box, having an electro-magnet mounted upon its upper surface, the armature of this magnet being firmly secured to one of its poles, but being not quite in contact with the other pole. The 'Exhibit Gray's Wooden Sounding Box Magnet Receiver' is precisely like the one just described, and I believe it to be the identical instrument. The armature I have referred to was an oblong rectangular bar, such as is now attached to the magnet. Part of the time a revolving drum receiver was used, being the instrument marked 'Defendant's Exhibit Gray's Animal Tissue Revolving Plate Receiver.' *Tunes* were transmitted by Mr. Goodridge and *accurately reproduced upon each of these receivers, in respect to* tone, pitch and quality. I think that other experiments were made, but the ones I have mentioned are the only ones which made a distinct impression upon my mind."

It will be observed that at this public exhibition of Mr. Gray's apparatus, described by Mr. Pope as a *common* reeceiver, was used, among others, for reproducing the tunes or signals transmitted. The instrument em-

ployed was, in fact, a magneto-telephone capable of reproducing composite tones and articulate speech.

In answer to interrogatory 8, Dowd Circuit Record, Vol. I., pp. 322, 323, 324, Mr. Pope further testified:

"Int. 8. State, if you please, in which of the apparatuses of Mr. Gray, and his practice therewith, known to you at the time of undertaking this search, you found embodied what you have described as the fundamental principles of the speaking telephone and state also why you regarded, and still regard, such apparatus and practice as embodying such fundamental principle, in view of the distinction of fact that in Gray's early apparatus and practice, to which you may refer, composite tones, consisting of several coexisting musical tones, were sent over the line and reproduced at the receiving end; whereas, in the speaking telephone, as commonly so called, articulate speech is uttered at the transmitting station and reproduced audibly at the receiving station.

"Ans. The opinion which I expressed in my report was based upon my knowledge of Gray's apparatus, which he had exhibited in 1875, and with which I had myself experimented at that time. I may state here that at the time of making this report I had no knowledge of the caveat which had been filed by Mr. Gray February 14, 1876, and that any question relating to that did not therefore enter into consideration. One of the experiments or exhibitions made in 1875 consisted of the transmission of tunes from a keyboard which formed a sort of electrical organ or harmonium, by which tunes were reproduced at another point on a *common receiver*. Each key of this keyboard, when depressed, transmitted a series of electrical vibrations through the line, and when two or any greater number of keys were depressed simultaneously, each key transmitted its own series of vibrations, they being, as it is technically termed, *superposed on each other, and forming a series of compound or resultant vibrations, all of which were faithfully reproduced upon the receiver, giving the effect which is termed in acoustics "quality of tone."* It was obvious to me that if a sufficient number of keys were employed that it was theoretically possible to so combine various simple tones as to build up any required composite tone, and that thus any sound whatever might be reproduced. This being the case, the apparatus now known as the speaking telephone, appeared to me to be a *particular application of the general method which was employed by Mr. Gray*, making use of an apparatus adapted to produce the particular character of composite vibrations requisite to reproduce articulate speech. I have no doubt that it would be possible to so arrange and combine a series of keys, as used by Mr. Gray, that articulate words might be produced at a receiving station by a proper manipulation of the keys, although, of course, such a

method would have little or no practical value compared with an apparatus in which the transmission is effected by the mechanical action of atmospheric sound waves upon a suitable transmitting apparatus controlling the electrical vibrations. For these reasons I regarded *the method of producing composite electrical vibrations in an uninterrupted circuit, acting upon a common receiver, as the essential feature of the articulating telephone*, the particular kind of transmitter or of receiver being a matter of secondary importance.

"I am confirmed in this opinion by the fact that although, since the date of my making that report, several different transmitters, of a character essentially different from each other, have been devised, and various kinds of receiving instruments—some without diaphragms, some without electro-magnets, yet all possessing a greater or less degree of efficiency—have been produced, *yet every system of articulate transmission of which I have any knowledge has embodied the fundamental principles which I have just referred to, and I do not conceive it to be possible, in the present state of knowledge, to devise such a system without building it upon the same foundation, however widely it may differ from existing ones in other respects.*"

In November, 1877, Mr. Pope being employed as an electrical expert and engineer (Dowd Circuit Record, Vol. I., p. 318), reported to the president of that company substantially to the effect that he regarded the fundamental principle of the speaking telephone to be the method of transmitting what are technically termed "*composite tones*;" that is to say, the simultaneous transmission of two or any greater number of tones over a single wire without destroying their individuality, and of simultaneously reproducing these tones at the receiving station, *a method which necessarily involved the use of a closed or interrupted circuit in the main line and of a common or universal receiver, capable of responding with facility to tones of every description, whether simple or compound.* Mr. Pope also stated that in his opinion this method was first invented by Elisha Gray.

Dowd Circuit Record, Vol. I., pp. 320, 321; O., pp. 3105–6.

At pages 329, 330, same record, Mr. Pope was interrogated as follows:

"Int. 16. In which of Mr. Gray's patents do you first find a description and representation of an apparatus involving what you have heretofore spoken of as the fundamental principle of the electric telephone, and under what special construction with reference to the receiving of the composite tone sent over the closed circuit?

"Ans. I find in Defendant's Exhibit Gray's Closed Circuit Patent No. 186,340, dated Jan. 16, 1877, a method of transmission involving the principle which I term the superposition of electrical vibrations, and which I have before stated was in my opinion the fundamental principle of the speaking telephone; but in this patent, instead of being applied to a common or universal receiver, as in the speaking telephone, it is here applied to a series of analyzing receivers, the object of the arrangement described being to separate the tones from each other at the receiving station. This patent describes, in fact, the precise arrangement for the simultaneous transmission of several different communications over one wire, which I have already stated I saw in operation in New York in 1875, being the first in order of the experiments I have described in my last answer. But substituting a common receiver for the analyzing receivers described in the patent, it represents the second experiment which I referred to."

At pages 333, 334 of the same record, Mr. Pope was requested to refer to any patents granted to Mr. Gray prior to January, 1876, which would describe the method of inducing electrical undulations in a closed circuit by the vibrations of a reed or diaphragm caused to vibrate by the impact of air waves accompanying the production of sound. In answer to the question propounded he refers to Mr. Gray's patents numbered respectively 166,095 and 166,096, dated July 27, 1875, and stated *that they described a method of producing electrical vibrations in a closed circuit* and *reproducing them upon a common or universal receiver*. The transmitting apparatus described in the patent is that known as "Gray's Two-tone Transmitter," and the common receiver referred to is what is designated "Gray's Magnet Receiver," consisting of an electro-magnet with a resonator placed upon or near its poles. The patents referred

to show and describe an induction coil in the primary circuit in which the transmitting apparatus is interposed and in the secondary circuit the receiving instrument is placed.

The witness also referred to Mr. Gray's patent No. 173,460, dated February 15, 1876, which relates to improvements in electric harmonic telegraphs. The invention in this later patent consists in combining with an organ or other wind pipe, a diaphragm vibrated by sounding said pipe and an electric circuit connected with said diaphragm, so as to be opened and closed by its vibrations.

Dowd Circuit Record, Vol. II., pp. 650, 651; **O**., pp. 3756–8.

After describing the method and apparatus set forth in these several patents, Mr. Pope says: "I find, therefore, that Mr. Gray's patents numbers 166,095, 166,096 and 173,460, when taken in connection with each other, describe and show a method of inducing electrical undulations in a closed circuit by the vibrations of a reed or diaphragm caused to vibrate by the impact of air waves accompanying the production of sound, and reproducing them upon a common or universal receiver."

Mr. Pope's statements and opinions are corroborated by Mr. Edward S. Renwick, an eminent mechanical engineer, who also testified in the Dowd case.

Dowd Circuit Record, Vol. I., pp. 206, 207, 208, 209, 229. **O**., 2991, 2992, 2993, 2994, 3014.

In December, 1874, Mr. Gray Constructed what is known as the "Wooden Sounding Box Magnet Receiver," and used the same with a multiple transmitter, giving a public exhibition therewith at Highland Park, Ill.

Dowd Circuit Record, Vol. I., pp. 86, 87. **O**., 2874, 2875.

A drawing of Gray's "Wooden Sounding Box Magnet Receiver" will be found in Dowd Circuit Record, Vol. II., p. 769.

O., 3898.

Gray's "Diaphragm Box Magnet Receiver" was used in connection with a transmitting instrument upon a telegraph line between Chicago and Milwaukee about the middle of February, 1875.

Dowd Circuit Record, Vol. I., pp. 88, 122.
O., 2876, 2907.

The apparatus so used was connected in a closed electric circuit similar to that shown in the diagram "Closed Circuit Single Tone Transmission Apparatus."

Dowd Circuit Record, Vol. II., p. 768. **O.**, 3897.

Professor Geo. F. Barker, an eminent physicist, a professor in The University of Pennsylvania, in an article on Telephony published in "Johnson's New Universal Encyclopedia," second and third biennial supplements, p. 293, thus refers to Mr. Gray's status as an inventor in harmonic multiple telegraphy and telephony. He says: "In May, 1874, he (Gray) constructed a "musical transmitter," having a series of reeds tuned according to the diatonic scale, with which he demonstrated that composite tones of varying quality could be transmitted and received telegraphically. This led him at once to the conception that articulate speech could be transmitted over a single wire."

"*Gray, therefore, seems to have been the first to formumulate distinctly the conditions necessary to transmit the form of the sound-wave electrically through a wire, and to devise a practical manner of accomplishing it.*"

We have already shown that as early as December, 1874, Mr. Gray had devised apparatus, whereby the proper amplitude of each vibration or succession of

vibrations, either simple or compound, could be reproduced by means of the electric current, and that he had thus solved the general problem of harmonic telegraphy and telephony.

Testifying in the Dowd Case (Dowd Circuit Record, Vol. I., pp. 123, 124), Mr. Gray says that his experiments in the latter part of January or fore part of Feb. 1874, known "as the bath-tub experiment" and others which he subsequently made, demonstrated to him that *quality* as well as pitch *could be electrically transmitted* and that he observed the same thing in all his experiments during the years 1874 and 1875. Referring to his experiments with a mechanical transmitter he says that it "confirmed what my previous experiments had led me to believe; that not only could the receivers that had been named be used as receivers of articulate speech transmitted electrically, but that such speech would be transmitted through or from a single point. I mean by single point without the intervention of a series of reeds or points differently tuned and one that would be a common or universal transmitter in the same sense that the receivers were universal or common.

In the month of November or December, 1875, Mr. Gray was in Milwaukee, Wis., and while there saw what is known as the "Lovers' Telegraph," and this aided him in the production of the speaking telephone described and represented in his caveat filed February 14, 1876. At page 124, Dowd Circuit Record, he was interrogated in relation to the invention of his speaking telephone, and testified as follows:

"Ans. The fact that all the vibrations, however complex or different in form, that are produced in uttering any given word or sound, were transmitted longitudinally through a fine thread suspended from the centre of a diaphragm capable of responding to all the aerial vibrations made by the uttering of a word or sound, and connected to a similar diaphragm at the other end of the thread, which might be from one to two hundred feet in length, proved to my mind that all the conditions necessary for the transmission of an articulate word were contained in any single vibrating point

capable of responding as before stated. I saw that if I could reproduce electrically the same motions that were made mechanically at the centre of the diaphragm by speaking upon it, such electrical vibrations would be reproduced upon a common receiver in the same manner that musical tones were; and from the fact that the electrical vibrations were the same in respect to rate, amplitude and form or complexity, as the motions made in the air by uttering words or sounds, it followed that the receiving diaphragm would be thrown into mechanical vibration or motion of a corresponding character, and consequently reproduce the same word or sound. The fact that the longitudinal movement (in water or other fluid of poor conducting quality) of a wire or some good conductor of electricity, with reference to another wire or metal conductor, produced variations in the resistance of an electric circuit proportional to the amplitude of movement, was old in the art at that time; so that the last link of knowledge necessary to solve the problem in my mind was furnished in the capabilities of the longitudinal vibrations of the string of the before-mentioned so-called lovers' telegraph."

Thus it appears that Mr. Gray had solved the general problem of harmonic telegraphy, and that the "lovers' telegraph" aided him by suggestion in making a particular application of his general method to the speaking telephone.

On the 14th day of February, 1876, Mr. Gray filed a caveat in the United States Patent Office setting forth that he had invented "a new art of transmitting vocal sounds telegraphically." The caveat will be found in the Dowd Circuit Record, Vol. II., p. 682; **O.**, p. 3799.

The object of the invention is stated to be "to transmit the tones of the human voice through a telegraphic circuit and reproduce them at the receiving end of the line so that actual conversations can be carried on by persons at long distances apart. Reference is also made in the caveat to the fact that Mr. Gray had invented and patented methods of transmitting musical impressions or sounds telegraphically, and that the invention in his caveat was based *upon a modification of the invention set forth in the Animal Tissue and Magnet Receiver patents of July 27, 1875.* The caveat also states that "to obtain the objects of my invention I

devised an instrument capable of vibrating responsively to all the tones of the human voice and by which they are rendered audible. The principle embodied in Mr. Gray's transmitter depends upon varying the resistance of the circuit by means of the sound waves. To a diaphragm of parchment or gold-beater's skin capable of responding to all the vibrations of the human voice, whether simple or complex, is attached a wire or metal rod extending into a vessel containing some liquid such as water, which wire or rod terminates close to a similar wire rising from the bottom of the vessel into the liquid. Through these wires and the intervening liquid the electric current passes, so that when, by the impact of a sound wave, the diaphragm is made to vibrate, the distance between the ends of the wires, that is, the resistance between their points, varies correspondingly; the vibrations thus imparted are transmitted through an electric circuit to a receiving station, in which circuit is included an electro-magnet of ordinary construction, acting upon a diaphragm to which is attached a piece of soft iron, and which diaphragm is stretched across a receiving, vocalizing chamber, similar in form to some ear trumpets.

The caveat states that "The diaphragm at the receiving end of the line is thus thrown into vibrations corresponding with those at the transmitting end, and audible sounds or words are produced."

The claim contained in the caveat is as follows:

"I claim as my invention the art of transmitting vocal sounds or conversations telegraphically, through an electric circuit."

On the same day that Gray's caveat was filed Mr. Bell also filed his application, upon which his Patent No. 174,465 was subsequently granted to him. In consequence of the caveat, Bell's application was suspended as required by law, and Mr. Gray was notified to complete his application for letters patent. It appears that Bell's application was filed a *few hours* pre-

vious to the caveat and that the Commissioner of Patents, on the application of Mr. Bell's attorneys, ordered the examiner in charge of the class of electricity to disregard the caveat, and thus Mr. Bell's first patent was issued and Mr. Gray was deprived of the privilege of contesting Bell's claim to priority of invention.

Mr. Gray testified in the Dowd case that at the time his caveat was filed he had never seen or heard of any apparatus for the telephonic transmission of speech other than that which was described and represented in the caveat. He assigned as a reason for filing the caveat (instead of an application) on the 14th of Feb., 1876, that at that time he had not constructed a model of the instruments therein described and shown.

Mr. Edward S. Renwick, being interrogated as to whether in his opinion Gray's caveat of Feb. 14, 1876, described and represented a practical apparatus for the telephonic transmission of articulate speech, stated that he had never had an opportunity of testing the operation of a transmitting instrument like that described in the caveat, but that from the statement of Prof. Bell as to the use of a similar instrument in Philadelphia at the Centennial Exhibition in 1876 he was of the opinion that the instrument was capable of transmitting articulate speech, and that he knew by actual trial that a receiving instrument like that represented in the caveat would receive and reproduce articulate speech.

Dowd Circuit Record, Vol. I., pp. 230, 231.
O., pp. 3015–16.

Unlike Mr. Bell's specification, Mr. Gray's caveat clearly sets forth that the object and purpose of his invention was "to enable persons at a distance to converse with each other through a telegraphic circuit," and he claims the art of transmitting conversations telegraphically. The caveat describes and the drawing

represents a telephonic apparatus capable of accomplishing the proposed result.

For clearness of description and illustration, Mr. Gray's caveat is in striking contrast with Mr. Bell's first patent, which deals in generalities and theories and says nothing about the transmission and reproduction of articulate speech.

If it be said that Mr. Gray had not constructed an apparatus wherewith he transmitted articulate speech prior to the filing of his caveat, we answer: Neither had Mr. Bell constructed an apparatus like that shown and described in his first patent, wherewith he transmitted and reproduced articulate speech prior to the date of his patent; nor did anybody afterward attain that result until about January, 1879. Moreover, Bell admits that the first articulate speech that he heard was obtained on the 10th day of March, 1876, with an apparatus substantially like that in Gray's caveat. In the specification of his patent Mr. Bell uses the phrase "vocal or other sounds," while Mr. Gray states in his caveat that the object of his invention is to transmit *conversations* telegraphically.

From the foregoing review of Mr. Gray's invention we respectfully submit that he anticipated Mr. Bell's first patent in that he first invented and discovered the true method of transmitting composite vibrations, which consists in causing the effective strength of the electric current by which the transmission is effected to rise and fall with the varying amplitude of the vibrations or waves which are to be reproduced. This method Mr. Gray employed in apparatus devised by him and publicly used the same before Mr. Bell's invention and he subsequently showed a special application thereof in his speaking telephone caveat.

From that caveat a person skilled in the art at the date thereof could have made a telephonic apparatus which would have transmitted and reproduced articulate speech.

Furthermore, we have shown that Mr. Gray constructed magneto-telephones, which were used as receiving instruments as early as the year 1874, and which were *then* capable of transmitting and reproducing speech.

BELL AND HIS PATENTS.

First Patent. No. 174,465.

We will now turn our attention to the inventions of Mr. Bell and to the history thereof. It is important to have before the Court the full and complete history of what Mr. Bell had done prior to the issue of the patent of March, 1876, in order that the patent may be construed by the light of such facts. Mr. Bell's work, prior to the issue of the patent, is a part of the history of the art, and in the light of the then existing state of the art and of what Mr. Bell had done in respect thereto, this patent must be construed. Such facts throw the same light upon any doubtful question of construction in the patent that existing and surrounding facts throw upon the construction of a statute or contract *inter partes*. In referring to this branch of the subject we shall draw considerably upon the judgment pronounced by Examiner of Interferences, Mr. J. B. Church in the interference cases in the Patent Office. That judgment was pronounced to a great extent upon the same facts that are now before this Court. All that Mr. Church had we have, but we have considerably more. The source of our information as to what Mr. Bell had done is substantially the testimony of Mr. Bell himself, modified by letters to and from him and by other written and printed matter during the period referred to. The testimony of Mr. Bell will be found in our record in the second part of the second volume, page 1586 *et seq.* From that page to page 1657 the testimony is a copy of

that given by Mr. Bell in the Dowd case in 1879. From 1657 to 1767 the testimony is a copy of the cross-examination of Mr. Bell by Mr. Hill in the Drawbaugh case. The whole testimony is adopted in this case by stipulation.

Mr. Bell was born in Scotland in 1847 and intended at first to follow the profession of his father, who was a teacher of vocal articulation, and by whom he was instructed in the anatomy and functions of the vocal organs, and in subjects bearing generally upon vocal physiology. He says that at an early age he invented a speaking machine and so constructed it that it was able to articulate one or two simple words. He also made; what he deemed, the first discovery; that the elements of speech were compound in their nature, and made a series of experiments to determine the characteristic tones of the vowels, and communicated the result to Mr. Ellis, of London, who informed him that the discovery had already been made by Helmholtz, who had proved the compound nature of speech sounds by producing such sounds synthetically by compounding the tones of tuning forks of different pitches, which were kept in continuous vibration by means of an electrical current. The discoveries of Helmholtz we have hereinbefore referred to; they are also stated in the testimony of Prof. Cross, to which Mr. Bell refers as stating them. The apparatus of Helmholtz, Mr. Bell says, consisted of a series of tuning forks of different pitches, which were kept in vibration by an electro-magnet placed near their prongs, and through the coils of which induction currents were passed by a *circuit breaker*, so that each tuning fork produced its own tone, and then, by means of resonators which could be brought into action at pleasure, Helmholtz intensified these partial tones more or less, or left some of them inaudible, at the distance at which the hearer was placed, and thereby produced the quality of sound of whichever vowel he pleased. This apparatus was

described to Mr. Bell by Mr. Ellis about the year 1867. Mr. Bell says that as a student of speech he felt it his duty to master all the researches of others that bore upon what was to be his professional study, and that he, therefore, desired to witness the results obtained by Helmholtz, and to investigate speech for himself in the manner shown by Helmholtz. He, therefore, began to study electricity, of which his knowledge was insufficient, and in the City of Bath, England, to make electrical experiments with a tuning-fork set in vibration by an electro-magnet. He says that from the year 1867 to 1870 he made numerous electrical inventions based upon the Helmholtz vowel apparatus, and that before he left England in 1870 he had made up his mind to pursue one of these inventions to a practical end. The invention to which he referred is now known as harmonic or multiple telegraphy. Mr. Bell says, in answer to interrogatory 9, that from the moment he became aware that Helmholtz had been able to produce vowel sounds with the aid of electricity, he believed that other elements of speech might also be produced in a similar manner; that while in England he formed no idea of the details of an apparatus for producing speech in that way, but did very distinctly have the belief that it was possible to construct such an apparatus; that he is sure that he stated to friends in England before 1870 his belief that we should one day speak by telegraph, but had no idea that he would ever himself be connected with the realization of such a plan. From the nature, however, of Helmholtz's apparatus, and from the subject matter that was then occupying the mind of Mr. Bell, it is evident that in using that language he does not mean that we should understand that he then had in view the transmission and reproduction of speech, but, as he says, "an apparatus for producing speech;" in other words, a sort of talking machine, the talking of which would be effected by means of keys operated by the fingers.

The attention of the Court is also called to the fact that at this early period Mr. Bell's attention was concentrated upon harmonic or multiple telegraphy, as the invention which he purposed to carry out to a practical end. The subsequent evidence shows that for many years he carried out that purpose with rare persistence and fidelity. In August, 1870, Mr. Bell's parents and himself removed to Brantford, Ontario (Canada). In April, 1871, Mr. Bell went temporarily to Boston, at the invitation of the Boston School Board, for the purpose of carrying on experiments with his father's system of physiological symbols in the Boston School for the Deaf; the object being to teach the deaf and dumb to articulate intelligibly.

In answer to the 13th interrogatory, Mr. Bell says that from the moment of his arrival in Canada in 1870, up to the commencement of 1874, his mind was full of the scheme for the multiple transmission of telegraphic messages by means of musical tones to which he had already alluded.

On the 1st of October, 1872, he moved to Boston, and from that time to the commencement of 1874, devoted all his spare time to practical experiments relating to the production of sounds by electrical means, with the object of reducing to practice the system of harmonic telegraphy.

The first instrument described and used by him is shown on page 1589, and was constructed in November, 1873, at Salem, Massachusetts. It is a modification of the apparatus employed by Helmholtz for vibrating his tuning forks, steel reeds being substituted for the tuning forks. The transmitter is substantially Helmholtz's transmitter or circuit-breaker, the normal rate of vibration of the reed determining the number of electrical impulses thrown upon the line. The receiver is provided with a reed (rod) whose normal rate of vibration is the same as that of the transmitter, and it is set in motion by the attraction of an electro-magnet

in circuit with the interrupter, the whole constituting an exemplification of Laborde's apparatus and system. On the next page, 1590, is shown a drawing of a receiver used by him at that time. During the experiments, and while using two circuit-breakers or transmitters on a single line with two receivers, the reed of one of the receivers failing to respond to its transmitter, was discovered to be of a different pitch, but was observed to have a sensible motion. Upon placing the ear against the receiver two tones were heard *similar in pitch* to the tones produced by the two transmitters and different from that normally produced by the reed itself. The discovery so made was thereafter occasionally utilized in adjusting the reeds of the receiver, and *for that purpose only*, as the success of the system demanded the exclusion of composite reproduction.

In answer to interrogatory 20a Mr. Bell says that observation of the force of the feeble vibrations produced in the reed of a receiver by the action of a current interrupter of different rate from its own was his usual method of ascertaining whether to shorten or lengthen the reed of a receiver. When the tone electrically produced was lower he lengthened the free portion of the reed; when higher he shortened the same, and thus adjusted its pitch to correspond to that produced by its proper interrupter. Further experiments on the harmonic system were made during the next month, December, 1873, involving the use of an induction coil with each transmitter or circuit-breaker, the receiver being in secondary circuit, and in the early part of 1874 another arrangement was tried, wherein several transmitters were placed in the primary circuit of a single induction coil, instead of a separate induction coil for each transmitter. It appears also that in the early part of 1874, Bell made use of two phonautographs not as part of his experiments in the electrical transmission of sound, but in the line of his professional duties—that is, the introduction of his father's method

of "visible speech," wherein a system of physiological symbols is employed as a means of teaching articulation to the deaf. These phonautographs were not original with Bell, but from the answer to the 23d interrogatory, page 1592, seem to have been constructed after the Scott phonautograph, referred to by Prof. Cross, or that of Duhamel, referred to by Reis. The instruments made by Bell consisted of a rod hinged by a piece of leather or cloth to the edge of a circular frame carrying a membrane. A small piece of cork fastened to the centre of the membrane and to the rod caused the latter to follow the vibrations of the membrane and record them on smoked glass. Mr. Bell says that he also "devised" an apparatus for repr[illegible]ng, by means of phonautograph sound tracings[illegible]unds similar to those which had made the tracir[illegible], but he did not construct any such apparatus (Ans[illegible]l and 28, pp. 1593–4).

The Court will note that this speculation which Mr. Bell's counsel terms "devising an apparatus" was a speculation for reproducing the sounds recorded by the phonautograph, *but not by electricity.* Mr. Bell also in the winter of 1873–4 "devised" a form of receiver for his harmonic system, in which the reeds were to be polarized by being attached to the poles of permanent magnets and placed opposite the poles of electro-magnets. He says that his method was to attach one reed to each pole of a permanent horseshoe magnet, the free end of each reed projecting from one pole of a horseshoe electro-magnet; that upon that plan he had one permanent magnet and one electro-magnet for each pair of reeds.

Up to this time the attention of Mr. Bell had been exclusively monopolized by the development of his harmonic system; he had made no efforts looking towards the reproduction of sounds, even, and his original ideas of the *production* of sounds by electricity had not, apparently, given place to the idea of their *reproduction.*

The facts so far stated also rest entirely upon the

testimony of Mr. Bell, and so far as the record discloses were witnessed by no person, except so far as his phonautographic experiments were made in conjunction with Prof. Cross.

Speaking of the instrument last above mentioned "devised" by him, Mr. Bell says in answer to the 32d interrogatory that in the summer of 1874 he devised a magneto-electric transmitter to work without a battery; that he saw that the receiver with polarized reeds, just before described, could be made to produce electrical currents if the reeds were caused to vibrate mechanically; he therefore devised an arrangement whereby each reed should be enclosed in a bed so arranged that the reed could be set in vibration by wind in the ordinary manner, as in organ reeds. These things which Mr. Bell claims to have "devised" do not appear to have been constructed by him; he stopped with the mental conception, although he produces a drawing which he says he made at the time, and which is shown on page 1595. Mr. Bell says (answer to interrogatory 35, in speaking of these "devised" instruments) that he understood from the well-known laws of magneto-electricity that a current of electricity would be induced in the coils of the electro-magnet *E*, figure 7, when any one of the transmitting reeds *A* moved downwards or upwards, and that the strength of the current would be proportional to the velocity of the motion of the reed. He, therefore, inferred that as the velocity of motion of the reed was increased, when the amplitude of its vibration was increased that the strength of the current produced by the vibration was also increased. In considering the effect upon the corresponding reed *A*, of the receiver it was evident that the violence of its vibration depended upon the strength of the electrical impulses passed through the coils of the electro-magnet E. He therefore reasoned that the more violent the vibration of the transmitting reed the more violent would be the vibration of the corresponding receiving reed; and the

less violent the vibration of the one, the less violent the vibration of the other. Thus, for every reed in the transmitter there was to be a reed in the receiver of the same pitch.

It is to be borne in mind that by this arrangement it was contemplated that "each reed should be enclosed in a bed so arranged that the reed could be set in vibration by wind in the ordinary manner, as in organ reeds," and the receiver was like the transmitter; so that a tone sounded by one was to be reproduced by the other, the whole being designed as a substitute for the circuit-breaker and tuned reed previously used in his harmonic experiments, the wind acting as the agent for setting in motion the reed only. In other words, this alleged conception or "devising" involved as a modification of the Laborde and Baile systems, the polarization of the reeds or armatures and the substitution for the circuit-breaker of a magneto-electric generator, the vibrations of the transmitter to be mechanically produced, however, instead of in response to external sounds. In order to reduce the number of magnets employed, Mr. Bell says he devised the instrument shown on page 1596 and denominated figure 8, and generally called the "harp instrument," wherein he attached a series of reeds to one limb of a horse-shoe magnet and used a single elongated straight bar electromagnet, the transmitter and receiver to be duplicates. Neither of these instruments was constructed.

In answer to the 37th interrogatory, Mr. Bell states his ideas conceived during the summer of 1874 concerning the transmission of articulate speech by electricity. His account of the mental conception and development of such an instrument is substantially as follows:

His acquaintance with Helmholtz's theories led him to believe that any of the sounds of speech could be produced by producing the musical tones of which such sounds were known to be composed, with their appropriate relative intensities. He was familiar with

the well-known experiment of articulating to an undamped piano, and had observed that the sound produced thereby approximated to that of the sound uttered in the vicinity and was due to the sympathetic vibration of those strings which correspond in pitch to the fundamental and upper partials or over-tones of the vowel, and that their amplitude of vibration corresponded to the loudness of the composite tones. Reasoning from analogy, he concluded that the "harp instrument," when constructed with a sufficient number of reeds graduated as to pitch, would serve to analyze the sounds of the voice into its component parts, and these reeds corresponding to the fundamental and over-tones would be set in motion like the strings of the piano, with the proper relative amplitude of vibration, inducing a current in the line which should affect the corresponding reeds of the receiver in the same degree and thus reproduce or copy the motions of the reeds at the transmitting end and produce a composite tone which should correspond to that operating upon the reeds of the transmitter.

It then occurred to him that inasmuch as there was but a single magnet to be influenced by the reed, the effect thereon would be but the sum of the vibrations of such reeds as were set in motion, and he argued in his own mind that this resultant effect might be produced by a single reed, if caused to vibrate in such manner as to represent the resultant of all the vibrations. Stretched membrane, he was well aware, would readily respond to sound vibrations, and his knowledge of the construction of the human ear, and experience in the use of the phonautograph and Koenig's manometric flame apparatus, demonstrated the capacity of such a membrane to communicate its vibrations to other objects; hence it occurred to him that if he attached the reed to a stretched membrane and talked against the latter, the complex vibrations incident to articulation, the resultant of tones and over-tones, would be

communicated to the reed and by its influence upon the magnet be converted into corresponding electrical undulations.

Mr. Bell makes these statements in answer to interrogatories 37 to 40 inclusive.

He says that he did *not* construct the apparatus described, because he had the idea that the magneto-electric currents produced by the operation of the voice would be *too feeble to produce* practically useful results. The Court will note, however, that this is Bell's original conception of *method*, or, in other words, the "method" originally conceived by him that it involves the *production* of a current by the action of the voice on a diaphragm. He says that in the summer of 1874 he did converse with some people respecting this arrangement, and illustrated the subject holding in his hand the human ear; but he cannot remember details or persons. On his return to Boston in September or October, he did, however, speak of his harp arrangement or plan for the transmission of articulate speech to Dr. Blake, Mr. Farmer, Prof. Lovering, and to one of the Professors of the Institute of Technology; also to Mr. Saunders in Salem, Massachusetts, and to Mr. Gardiner G. Hubbard in Cambridge. He says that in speaking to Dr. Blake of the matter, he made sketches to illustrate his description of his inventions, and his answer to the 47th interrogatory says that he produces them. The sketches, however, are not in our record; they may be found in Volume IV., Complainant's Exhibits, of the Drawbaugh Record, on page 995.

Speaking of the instrument shown by these figures, Mr. Bell says, in answer to the 48th interrogatory, page 1599, that he had the idea that magneto-electric currents generated by the vibration of a polarized tongue were *very feeble*, and therefore sought to increase the effect by combining together three permanent horse-shoe magnets, as illustrated in the figure. He says that figure 3 represents a galvanometer in circuit with a straight-

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bar electro-magnet, over the pole of which a polarized or magnetical tongue is placed; that he made this drawing for the purpose of explaining to Dr. Blake the peculiarities of the electrical current produced by vibration of a magnet in front of an electro-magnet. He says also that the other illustration, termed figure 4, represents the first apparatus he had conceived for the transmission of vocal utterance electrically; that it is the same harp instrument shown before in figure 8 on page 1596. Mr. Bell says that he has a recollection of asking Dr. Blake's opinion as to whether the human voice could vibrate the membrane with attached armature, and that he got the impression from Dr. Blake's remarks that it could, if the membrane were made concave like that in the human ear, and if the end of the armature were attached, not to the centre of the membrane but to a point a little one side corresponding to the point of attachment of the malleus and tympanic membrane of the ear. Mr. Bell fixes the time of this conversation with Dr. Blake by reference to a letter received from Dr. Blake, dated October 21, 1874, in which Dr. Blake referred to some letter that he had received from Mr. Elisha Gray concerning experiments in telegraphing vocal sounds; that he thereupon visited Dr. Blake and told him that he did not wish to see Gray's letter, as he was then engaged upon the problem of transmitting articulate speech by electricity and did not wish to be indebted to any one for information on the subject—which is a little curious, as he was just then asking information from Dr. Blake with reference to the probable capacity of the instrument devised by him.

From this testimony it is apparent that Mr. Bell would have us believe that by and prior to the time of his conversation with Dr. Blake he had evolved a theoretically complete and efficient instrument for transmitting the human voice, while at the same time he concedes that no effort was made to demonstrate by

experiment its value, nor was any expression given to his views. Mr. Bell was peculiarly impressed with the importance of such a discovery, and he was engaged in such experiments upon the electrical transmission of sound that there would seem to have been no difficulty. had he so desired, to test his theories. The excuse he gives is that he had the idea that the magneto-electric currents produced by the operation of the voice would be too feeble to produce practically useful results (Interrogatory 43, p. 1598).

Mr. Church, in commenting upon this point in the history of Mr. Bell, says that this explanation

> "Does not accord well with the elaborate deductions he had drawn from experience. It is true that this reason for not testing the harp instrument was given in the preliminary statement, sworn to May 8, 1876, filed in the Multiple Telegraph Interferences, but no mention was then made of the reed and membrane, and it seems a little strange that an instrument should have been so elaborately reasoned out, when the principle upon which it was founded was supposed to be erroneous and inadequate. Some allowance must also be made for the natural tendency of the mind to magnify and enlarge upon a favorable phase of early mental processes, particularly when, as in the present instance, subsequent events develop striking analogies. Contemporaneous evidence, written or oral, as to the metes and bounds of his idea there is none; slight and apparently insignificant errors in this science as in mathematics vitiate the whole process and result in complete failure; consequently the law prefers demonstration to mere theories, and requires that elements entering into the calculation shall be evidenced by some person other than the inventor. The expression of a desire, a hope, a purpose or an ability to perform or accomplish certain results, without defining the means to be employed and method to be pursued, is not proof of invention, and more especially is this the case when the object sought has reference not to an improvement, *but to an entirely new art or machine.* Therefore we must look beyond the mere testimony of the party as to mental transactions, and demand that he shall substantiate his claims by some corroborating contemporaneous evidence."

We are not now concerned in the immediate question which occupied the mind of Examiner Church; he was questioning the time of Mr. Bell's invention—we are

more immediately asking the attention of the Court to the character of Mr. Bell's invention. It is apparent that up to this point his whole mind was imbued, for whatever purpose, with the idea of the use of the magneto-electric current and with the method he had conceived for producing it; that it was *that alone* which he conceived might be made useful in transmitting speech by electricity, and that he was so thoroughly and completely impressed with the utter uselessness of *that* current for practical purposes because of *its feebleness* that he made no attempt to practically realize the conception, which he regarded as theoretically perfect and complete that therewith (if strong enough) he might transmit speech. This inaction is the more remarkable in view of the fact that he then must have understood, as his answer to interrogatory 51 would indicate, that Mr. Gray was engaged on the problem of transmission of articulate speech, and that unless he was willing to be anticipated by Gray, the utmost diligence was incumbent upon him to perfect his invention, resting so far only in conception. He, however, did not do so. On the contrary, he did most thoroughly devote himself to the problem of harmonic or multiple telegraphy, and there can be little question that it was anticipation in that line, and not in the way of transmitting speech, which he apprehended from the activity of Prof. Gray.

In February or March, 1875, Mr. Bell had a conversation with Prof. Henry in Washington, and detailed it in a letter to his parents, printed on page 1601 *et seq.* He detailed to Prof. Henry the experiment of passing an intermittent current of electricity through an empty helix of insulated copper wire and hearing a noise proceeding from the coil similar to that heard from the telephone. Mr. Bell was so gratified by the interest taken in his experiment by Prof. Henry that he explained, he says, to Prof. Henry, and asked his advice about the apparatus he, Bell, had designed for the transmission of the human voice by telegraph. That

Prof. Henry thought the idea was the germ of a great invention and advised him to work it out himself, instead of publishing. Mr. Bell stated that he recognized the fact that there *were mechanical difficulties* in the way that rendered the plan *impracticable* at the present time, and added that he felt that he had not the *electrical* knowledge necessary to overcome the difficulties; and that Prof. Henry laconically answered, "Get it." Mr. Bell adds that such a chimerical idea as telegraphing vocal sounds would indeed, to most minds, seem scarcely feasible enough to spend time in working over it; he believed, however, that it was feasible and that he had the cue to the solution of the problem. What it was which Mr. Bell explained to Prof. Henry does not appear, but in a letter to Mr. Hubbard, dated May 4, 1875 (page 1604), mention is made of a letter from Prof. Henry in answer to one from Bell explaining some experiment the latter had undertaken for the purpose of determining the cause of the sound heard from the empty helix, wherein Bell states: "The deduction I had made from the experiment was that an intermittent current of electricity creates a molecular vibration in the conductor through which it is passed." This chain of thought and experiment resulted in a discovery, original though not new, as he afterwards learned, that an intermittent current of electricity created a molecular vibration in the conductor through which it passes, and this property he thought to utilize for the transmission of sound. In this same letter of May 4th, after mentioning an experiment he purposed to try—that of passing an intermittent current through the strings of a piano, with the expectation that the string whose rate of movement coincides with the molecular vibration induced in the wires by one of the transmitters will resound loudly, he continues:

"Another experiment has occurred to me, which, if successful, will pave the way for still greater results than any yet obtained.

The strings of a musical instrument in vibrating undergo great changes in molecular tension; in fact, the vibration is the result of the struggle between the tension of the string and the moving force impressed upon it. I have read somewhere that the resistance offered by a wire to the passage of an electrical current is affected by the tension of the wire. If this is so, a continuous current of electricity passed through a vibrating wire should meet with a varying resistance, and hence a pulsatory action should be induced in the current. If this turns out to be the case, the oscillations of the current should correspond in amplitude, as well as in the rate of movement, to the vibrations of the string, and one consequence would be that the *timbre* of the sound should be transmitted. *The plan* for transmitting *timbre* that I explained to you before, viz., causing permanent magnets to vibrate in front of electro-magnets, is generally defective on account of the *feebleness of the induced currents.* If *the other plan* is successful, the strength of the current can be increased *ad libitum* without destroying the relative intensities of the vibrations."

The Court will notice the contrast in the mind of Mr. Bell of the *two plans* for transmitting *timbre* here referred to. The one plan, which he calls the *magneto plan*, is his first conception and of the impracticability of which he had been so convinced that he had never tried to realize what he regarded as perfect in theory. He, in this letter presents the theory of the *other plan*, which is a varying of resistance by vibrating the conducting wire. He seems similarly to have as yet made no experiments with this second plan.

In his answer to the 64th interrogatory, Mr. Bell enlarges upon the matter referred to in his letter of May 4th. He again states that he had the idea that magneto-electric currents generated in the way shown in his harp instrument would be too feeble for practical purposes. Within a day or two after the letter was written, the experiment was made with the piano, and was a failure. He seems to have made no experiment by way of vibrating wire in the manner he referred to until some time in the year 1879, when he tried it listening with a hand-telephone then known, and was able to discover a faint tone (see Record, page 1608, answers to Interrogatories 68 and 69).

This speculation of Mr. Bell as to what might be done by vibrating a wire, the Court will note, is the only thing in the course of his thoughts or experiments, as detailed by himself, having the least reference to the idea that speech could be transmitted by what is now called the "microphone method," in contradistinction to a *plan* or *method* which apparently was always, more or less, in his mind from the time of its first conception called the *magneto-electric method.*

We now come to an experiment, or accidental discovery, which has been made of great importance in this litigation. On the 2d of June, 1875, Mr. Bell addressed to Mr. Hubbard a letter in which he says:

"I have recently made a discovery of the very greatest importance in regard to the transmitting instruments. Indeed, so important does it seem to me that I have written to the organ factory to delay the completion of the reed arrangement until I have had an opportunity of consulting you. I have succeeded to-day in transmitting signals *without any battery whatever.* A musical note produced at the receiving end was sensibly the equivalent of that at the transmitting end, *in loudness as well as pitch.*"

At the time of conducting this experiment, Mr. Bell was engaged in experimenting with reference to his system of autograph telegraphy based upon his harmonic system. In this he was assisted by Thomas A. Watson. A series of interrupters, or circuit-breakers, with separate keys for connecting them with the main line at one station, and a series of harmonic receivers were stationed at two points on the line; each receiver consisted of a horseshoe electro-magnet, with a reed (corresponding in pitch to one of the interrupters) fastened to one leg, and a coil of insulated wire surrounding the other. It was the design that one of the receivers at each station should respond when the interrupter whose rate of vibration corresponded to that of the reed should be connected by depressing its key. In testing the apparatus, one of the reeds at Watson's station failing to respond, he was directed to pluck it,

as that means was sometimes adopted for starting the reed when it had become attached to the pole of a magnet. He did so, and Bell observed that the corresponding reed at his station was thrown into vibration, though he did not depress the key of the transmitter. He was at a loss to understand where the current came from to operate the reed, and to make sure that it was derived from the transmitters, he cut them out entirely and connected the two receivers upon a circuit without a battery. Upon plucking with the finger any reed at one station, it was found that the corresponding reed of the other station was thrown into sympathetic vibration; upon placing the ear at each reed the peculiar tone of the reed plucked at the other station could be recognized, and Mr. Bell says that he recognized that the *timbre* of the plucked reed had been reproduced. Mr. Bell supposed that when the apparatus was used without a battery, the electrical impulses were generated by the residual magnetism caused by the passage of heavy battery currents through the coil, and that the vibration of the reed when plucked by the finger had occasioned a magneto-electric current upon the circuit similar to that which he had intended to produce by the vibration of the reeds of the harp instrument devised in Canada. He says that these experiments solved the difficulty that had been in his mind since the summer of 1874, in regard to the practical operation of the various instruments which he had devised, though not constructed, for the reproduction of vocal utterance by electrical means. He had had the idea that magneto-electric currents generated by the vibration of permanent magnets or reeds would be *too feeble* to produce any useful practical results; these experiments assured him that he had been mistaken in that idea, and he thereupon gave instructions to Mr. Watson to have his membrane arrangement constructed. It was constructed, but instead of hinging a steel reed, as he says he had intended, Mr. Watson, he says, used

a thick armature which was pivoted to the pole of its electro-magnet. The uncovered leg of the magnet to which that armature was attached was removed a day or two after and another substituted for it; the pole of the uncovered leg was filed to an edge and a steel reed was hinged to it by means of a strip of leather. Experiments were made with this instrument *without waiting* to have the duplicate receiver made. They seem to have been a complete failure, for nothing is stated by Mr. Bell with regard to them except that he was encouraged to reconstruct the instrument with a lighter armature. The first test, Mr. Bell says, was with a battery, which at once tore the membrane. These appear to have been the only experiments conducted with a membrane instrument in June, although, as Mr. Bell testifies (page 1614), during the month of June he was constantly occupied in experimenting to ascertain the the best arrangement of his coil, magnet and armature for generating electric currents by the vibration of a reed in front of an electro-magnet.

The fair inference from this is that the experiment with the membrane was incidental to some other invention upon which Mr. Bell was then engaged, and that the results obtained were not very strongly marked or reassuring, notwithstanding his claims and assertions to the contrary. The experiments upon which he was mainly engaged, and to which the membrane instrument would appear to have been a subsidiary or modified form, belong to the multiple harmonic system. The letter of Mr. Bell to Mr. Hubbard, of June 28, 1875, strongly supports this theory. It is in these words:

DEAR MR. HUBBARD—Mr. Hutchings (the organ builder) kindly devoted the whole of this afternoon to the construction of a steel reed for me. One of the latest receiving instruments was enclosed in a wooden box and had its armature so arranged as to be set in vibration by a current of air passed through the box. The instrument was completed this evening in time for trial. Mr. Hutchings operated the reed in a little room upstairs (Williams' office), while

I observed the effect upon a receiving instrument placed in the basement of the building. The sound was so perceptible that I found it unnecessary to place my ear against the instrument. The vibration of the armature could also be seen and felt. No battery nor permanent magnet was used. I feel sure that a study of Ladd's or Wilde's magneto-electric machines will reveal a means of increasing the intensity of the induced currents. I am told that Prof. Lovering has one of Wilde's instruments in his possession, so I shall call upon him to-morrow for information concerning it. Prof. Pickering has left town for the summer. I propose having the steel reed still further altered to-morrow, so shall probably be at the organ factory most of the afternoon instead of at Williams'. Shall call in the evening and report progress.

P. S. The experiment referred to above was repeated; when a single cell of a battery had been placed in a circuit, the amplitude of vibration of the armature downstairs was quite large enough to work the vibratory circuit-breaker. We were unable to try higher battery power on account of the sticking of the generating armature; when the instrument is altered to-morrow I shall try higher battery power and test the resistance, through which the current will pass.

The latest "receiving instrument" referred to in the commencement of the letter was undoubtedly to perform the functions of the circuit-breaker previously employed, the current of wind merely operating to vibrate the reeds and the induced currents to set in motion similarly-tuned reeds. His statement that "the amplitude of vibration of the armature downstairs was quite large enough to work the vibratory circuit-breaker" points directly to the system of autographic telegraphy upon which they were at work, and which is described in Bell's patent of April 6, 1875, and referred to in the patent of March 7, 1876, on which the bill of complaint herein is filed.

On July 1, 1875, Mr. Bell writes to Mr. Hubbard: "The experiment to which I alluded when I saw you "last promises to be a grand success. On *singing* this "afternoon in front of a stretched membrane attached "to the armature of an electro-magnet the *varying* "*pitch* of the voice was plainly perceptible at the other "end of the line, no battery nor permanent magnet be-

" ing employed. When the vibrations are received " upon *another stretched membrane in place of a steel* " *spring*, it is possible—nay, it is probable—that the " *timbre* of the sound will be perceived. I hope to try " the experiment to-morrow afternoon."

Whether or not the idea of a receiver of this kind was contemporaneous with the conception of a transmitter does not definitely appear. The first mention that Mr. Bell makes of it in his testimony is the explanation of thoughts supposed to have occurred at the time the letter of May 4, 1875, was written, and where he says he intended, when he had Watson make his first membrane transmitter in June, 1875, to have a duplicate made for a receiver. In this letter of July 1, 1875, we find the first disclosure of such an idea and coupled with the statement that "it is *possible*, nay, it is probable that the timbre of the sound will be perceived," which is not the statement of a man who was confident or who thought that he had already solved the problem of the transmission of speech.

The first trial of a membrane transmitter was made *with the harmonic receiver* to satisfy Bell's desire for an immediate test, as he says; but it was not until July 1, the day this letter was written, that he gave orders for the construction of the second instrument (see page 1615 and 84th answer). Mr. Bell tells us of no successful results of his first trial other than that he was encouraged to reconstruct with a lighter armature (see Answer 77). The experiment with this second instrument seems to have produced no substantially better result. It was the first experiment wherein a membrane receiver was used. Bell says that Watson rushed up to the room where he was, and said that he could distinctly hear Bell speaking, though he could not quite make out what he said. He had satisfied himself that the sounds he heard had been produced by the membrane telephone to which he had been listening (Answer 90, page 1615). Mr. Bell

says that he considered that this experiment demonstrated the practicability of transmitting articulate speech by instruments having the same mode of operation and principle as these stretched membrane instruments, and that it was only necessary to make further experiments to ascertain the best arrangement of the parts. On his cross-examination by Mr. Hill (page 1660, Answer 293) Mr. Bell says that in the summer of 1874 he became convinced that he had devised a *method* and apparatus by which the sonorous vibrations of the air could be caused to produce similar sonorous vibrations in the air of a distant place; that there was no doubt in his mind that if the reproduced vibrations were sufficiently violent that they would affect the ear as a sound of similar character or quality to that produced by the original vibration—that is, he became convinced in the summer of 1874 that he had arrived at the true conception of a speaking telephone. The chief doubt in his mind at that time was as to the practical value of the reproduced speech. He saw that while the reproduction of the original vibrations would be perfect they would be copied in miniature; they would be, as it were, microscopic photographs of the originals. In other words, they could not be heard. He was doubtful whether the unassisted ear could perceive the vibrations as sound, and whether if so, the minute details of the vibrations, upon which depend the character or quality of the sounds produced would be perceived by the sense of hearing. At that time he proposed to take advantage of magneto-electric currents produced by the vibration of an armature actuated by the voice of a speaker, so that the electric current employed *would be produced by the action of the voice itself*, and not independently of it; hence the reproduced vibrations would necessarily be very much feebler than the original, and it was questionable in his mind how far they would be of practical value.

During the winter of 1874 and spring of 1875 this

feeling led him to seek some *method* by which the voice, instead of producing the electric current used, should merely modify the current produced by other means. In May, 1875, he "*devised*" a method of varying the resistance of a galvanic current by the action of the voice, in the hope that this would obviate the supposed insufficiency of the magneto-electric current and produce practically operative effects; that he was still carrying on those experiments and researches regarding that *method* when the accidental discovery made on the 2d June, 1875, proved that the supposed insufficiency of a magneto-electric current to produce audible effects was a mistake; that he then immediately ordered the construction of the speaking telephone just above referred to. He says (page 1663) that he satisfied himself by listening at the receiving telephone that the articulation was there, although he cannot recall the details of any particular experiment in which he heard words or sentences. He was satisfied with having obtained audible results at all, for he knew from theory that the articulation was there, and he was convinced that the instrument had only to be properly made, and tried under suitable conditions of experiment, to be practically operative; that the greater portion of his time, therefore, after the 1st of July, was taken up in experimenting with vibrating reeds and permanent magnets in front of electro-magnets, with coils varied in different ways, to arrive empirically at that arrangement which would produce the most violent effects. Few, if any, experiments of any kind were made between the end of July and the date of the patent, and he can remember of none.

We may here remark that this confidence from his theoretical knowledge not stated by Mr. Bell to have then existed is somewhat inconsistent with the state of mind described in the foregoing letter of July 1st, 1875, wherein he spoke of the desired result as "possible—nay probable."

On page 1672, cross-question 318, Mr. Bell is asked :

"In your patent of March 7, 1876, I understand figure 6 of the drawings to represent three stations of a harmonic or multiple telegraph system. Without reference to the question about whether you had your instrument of June 2d connected in series or multiple arc, I wish to know how far this figure 6 represents the apparatus with which you commenced those experiments of June 2d; and I will state that, as I understand your testimony, if the instruments A, B, C of the left-hand station directly over the battery, as shown in said drawing, were removed, and your circuit-interrupters and telegraph keys substituted therefor, then said figure 6 would be a pretty correct representation of your apparatus at the beginning of your June 2d experiment; please state whether my understanding of your testimony is correct, and, if not, wherein it is incorrect?

"A. I think that figure 6 would, with the alterations you suggest, and a return wire instead of the earth, be a substantially correct diagram of the arrangement used in the experiment referred to, assuming the instrument to have been connected in series as shown."

Mr. Bell goes on to state, in answer to questions, that the instruments used by him in the experiment of June 2d consisted at the transmitting station of circuit-interrupters with a telegraph key for throwing them in and out of circuit; whereas in the drawing, figure 6, in the patent, the transmitting station consists, not of circuit-interrupters and telegraph keys, but of magneto-transmitting reed instruments arranged in the circuit. He is then asked (question No. 321) :

"Now, referring to this transmitting station, it is true, is it not, that your passage from the circuit-interrupting apparatus, which you were using at the beginning of that June 2d experiment, to the magneto-transmitting reed instruments shown in the left-hand station of figure 6 of your said patent of March 7, 1876, as a transmitting apparatus, was one of the results of that discovery of June 2, 1875?"

The answer is :

"Oh, no; not at all. I had made a transition in theory long before, but up to the date of the experiment referred to I had presumed that the magneto-transmitting reed instrument would produce so much

feebler effects than the circuit-interrupting apparatus that I feared that they might not prove sufficient for the purpose of my inventions. The experiment of June 2d occasioned the great change in my opinion regarding this point, and this was the chief result of the experiment made that day."

"Q. 322. And that change of opinion caused you to substitute magneto-transmitters in place of the circuit-interrupters, did it not?"

"A. If by 'substitution' you mean giving up the circuit interrupter, it did not. The vibrations produced in the receiver by the action of the circuit interrupter seemed to be more powerful than those produced by the magneto-transmitters mentioned, and I felt that they might well be utilized for certain purposes in my system of multiple telegraphy; but when it was designed to transmit many Morse messages simultaneously on the same circuit, I believed that the magneto reed instruments would permit of the transmission of a very much larger number of messages without interference with one another than could be possible with circuit-interrupters."

"Q. 323. Your belief that when it was designed to transmit many messages simultaneously on the same circuit the magneto reed instruments would permit of the transmission of a very much larger number of messages without interference with one another than would be possible with circuit-interrupters, was a belief that had its origin in the experiment of June 2, 1875, and the discovery that you made that day, was it not?"

"A. No; it had its origin long before, but I had feared until the 2d of June, 1875, that the instrument would not prove in practice as perfectly adapted for my purpose on account of the feebleness of the vibrations of the receiving reeds as they were in theory. My thorough and complete belief in the practicability of using such instruments in anything more than laboratory experiments dated from the experiment referred to; all the theoretical part had been developed long before that time. There was only one difficulty in my mind—the supposed feebleness of the effect; the discovery of June 2d merely removed this difficulty."

"Q. 324. Then, the discovery of June 2d consisted simply in this—that the magneto current produced by vibrating an armature in front of the pole of an electro-magnet was stronger than you had supposed; was that the fact?

"A. Partly. The chief difficulty in my mind was as to the violence of the sonorous effect at the receiving end produced by the action of this current. I had feared that it might not be sufficiently audible for practical purposes; the discovery of June 2d consisted chiefly in this—that it was."

"Q. 325. And when you made that discovery, then you availed yourself of it by reorganizing your apparatus upon the plan shown

in figure 6 of your patent of March 7, 1876, as one result of the discovery, did you not?"

"A. Certainly; but I don't think I did so immediately. The moment the discovery was made, the practicability of the speaking telephone '*devised*' by me in 1874 flashed upon me, and I instantly gave instructions to have the instrument made." (But it was not made for a mouth). "I was too much excited over this to attach more than secondary importance to multiple telegraphy at the time. I had already, as I have stated above, arrived theoretically at the arrangement shown in figure 6 and within the next few days after June 2d, and on that day I made experiments that demonstrated to my mind that the whole arrangement shown in figure 6 was practical.

"Q. 326. When did you, for the first time, actually put together and experimentally operate a system substantially the same as that shown in figure 6 of said patent?

"A. I cannot say precisely, but *somewhere in June or July*, 1875, *I think in June.*

"Q. 327. And when did you, for the first time, actually put together and experimentally operate the combination of instrumentalities as shown in figure 5 of said patent drawing?

"A. June 2d, 1875.

"Q. 328. At the beginning of your experiment of June 2, 1875, you had already had in your possession previously constructed all the several instrumentalities shown in said figures 5 and 6, but had never combined them together as here shown if I understand you; am I right?

"A. I had never combined the instrumentalities in figures 5 and 6 precisely as shown, but I have no doubt that they were often previously combined in that way in my experiments unintentionally.

"Q. 329. But until June 2d, 1875, without the discovery of any practical utility in so combining them?

"A. The only utility I had in view in such experiments was their use as receivers for current-interrupting transmitters."

"Q. 330. How long prior to June 2d, 1875, had you had in your possession instruments substantially like the magneto receivers or the transmitters shown in figures 5 and 6?"

"A. The instrument shown in figures 1 and 3, pages 109-111 of my deposition, I had in November, 1873, as there stated. I consider them substantially the same for the purposes of this question, though there are some differences of construction which I can explain if required. The instruments of figure 5 of the patent are improved forms of the same receiving instruments shown on pages 109-111 of my deposition. I should think that such instruments might be substituted for those shown in figures 5 and 6 of the patent, with substantially the same results."

In his 340th answer Mr. Bell had stated that prior to June 2d, 1875, he was extremely doubtful whether the magneto-electric currents would be sufficiently strong to produce audible effects, either for the purpose of reproduction of articulate speech or for the purpose of multiple telegraphy. He had hoped that they might prove of sufficient force, but was unable to decide simply from the state of knowledge at the time, without practical experiments to test the point. In question 344, pp. 1679, 1680, he was asked:

"Then, the doubt which you spoke of in your 340th answer was so strong and the hope so weak, that although the generation of undulatory currents in a circuit by the inductive energy of the vibrating magnet or plate in front of the pole of the electro-magnet suggested itself to your mind as early as July, 1874, and although for the purpose of reproducing articulate speech by electrical means it was of the greatest importance to determine whether electrical undulations so caused in the line would produce sonorous vibrations of the vibrating reed or not; and although you had in your possession all the instrumentalities for the demonstration of the question; and although, having those instrumentalities, the experiment was an exceedingly easy one to make, yet from July, 1874, to June 2d, 1875, you never made the experiment, nor attempted to make it, nor attempted to ascertain whether your doubt was well-founded or not, and the experiment of June 2d, 1875, which finally resolved your doubt, was an experiment relating to the multiple telegraph, in which the resolving of your doubt was purely an accidental matter; am I correct?"

In his answer Mr. Bell attempts in various ways to explain and account for the delay—among others, expense and lack of time; and yet immediately afterwards in the succeeding questions he is obliged to confess that with the instruments he had, the expense would have been nothing and the time required inappreciable. His answer also does show that the solution of the problem of multiple telegraphy was regarded by those pecuniarily interested with him as of vastly greater importance, and that that problem was earnestly pressing upon the minds of himself and his partners interested.

Now, taking the letters of June 2–28 (pp. 1609 and 1613),

to Mr. Hubbard, and this testimony of Mr. Bell relative to the transactions of himself and Mr. Watson during the month of June and prior thereto, we submit that it is perfectly apparent that they were engaged upon experiments relative to the use of the magneto-electric current for the purpose of multiple telegraphy, rather than for the purpose of the transmission of speech. The great discovery of June 2d was primarily to be applied, and was primarily applied, to the harmonic system; the trial of the membrane was ancillary and supplementary to the main idea. In this way we can explain the apparent neglect of the membrane transmitter after its unsuccessful trial; it was to be employed as a substitute for or modification of the tuned reed transmitter. This accounts for its use with the harmonic receiver and his failure to mention any other form of receiver. Mr. Bell may have conceived that with such a transmitter as he constructed he could convey speech; this was what he says he told Dr. Blake, in October, 1874, but he had relied upon the receivers which he then had; when tested, they failed. In the letter of July 1, 1875, he refers to an experiment alluded to in a conversation had with Mr. Hubbard, and says it promised to be a grand success. The membrane transmitter was tried with the harmonic receiver, it is presumed (for no new form is mentioned) and the "varying *pitch* of the voice was plainly perceptible at the other end of the line." No such result had before been obtained. Thereupon he announces:

> "When the vibrations are received upon *another* stretched mem-
> "brane in place of a steel spring, it is possible, nay, it is probable,
> "that the *timbre* of the sound will be perceived."

For the purpose of carrying into execution the design of a membrane receiver expressed in this letter, he, on the same day, July 1, 1875, instructed Mr. Watson to make a second membrane telephone, and it was com-

pleted a day or two later; it is substantially the same as the first instrument. If we refer to Watson's testimony as to the result of this trial of the two membrane instruments, we find that he simply says that he thinks the results were a slight improvement on what they had previously obtained (see page 1773, 15th answer); and Watson describes the results which had previously been obtained simply as "a faint sound" (Answer 13, page 1777). The conclusion of Mr. Bell, that at this time he considered that he had solved the problem of transmitting speech, seems remarkable. His experiments had signally failed to approximate to such a result. Giving the utmost latitude to his own memory of his intellectual condition at that time, it must be only that he had so much confidence in the method theretofore devised by him for the transmission of speech by means of a current *created* by the voice, that the mere fact of the magneto current proving strong enough to produce any audible result was sufficient to satisfy him that instruments could be *thereafter* devised and constructed sufficiently delicate and accurate to carry into effect his pre-existing intellectual conception. In other words, it was a conviction upon his own mind that with the *method of* creating a current by the voice, he would be able to solve the problem of the electric conveyance of speech. He had not done it. The apparatus to carry into practical effect his device or conception remained to be invented. This second membrane instrument, as we have seen, was ordered July 1st and finished a day or two thereafter. Precisely when during the month it was tried does not appear. His experiment preceding that trial of the second membrane instrument was made with a single membrane instrument as the transmitter, and with a reed only as the receiver. On the 7th of July, 1875, he wrote a letter to Mr. Hubbard, found on page 1616 of the Record. This letter speaks of the gratifying result obtained with the steel

reed, and describes the experiments therewith and then says :

" This seems to me to indicate more power than can possibly be " due to magneto-electric currents generated by the vibration of the " reed. May not a pulsatory action be induced in the voltaic cur- " rent itself by the motion of the reed ? I can imagine the current " alternately weakened and strengthened according to the distance " of the armature from the pole underneath ; in this case the pul- " sations would certainly be available for our purpose by merely " increasing the battery power sufficiently to overcome the resist- " ance of the line. Magneto-electric currents are, however, evi- " dently present, for a sound is perceptible at the receiving end " when the battery is omitted altogether."

The letter contained a drawing of the instrument with which he had been experimenting, omitting the resistance introduced into the circuit ; the figure as shown in the letter is substantially identical with figure 5 in his patent of March 7th, and the Court will note the idea suggested in this letter and stated in the patent of a pulsatory undulatory action induced in the voltaic current itself by the motion of the reed or armature ; a notion the fallacy of which is shown equally by all the experts on the part of the defense and by Prof. Cross himself, the expert of the complainant. They all agree that the only function of the voltaic current is to magnetize the cores of the electro-magnets, and that it is absolutely without function so far as effecting work in the transmission of speech, or in the vibration of the diaphragm or reed of the receiver ; such work, such vibration being effected exclusively by the magneto currents generated by the vibration of the armature in front of the poles of the magnet of the transmitter. It is apparent, too, that the arrangement thus suggested in the letter, with the mode of operation suggested by the legends respectively under the transmitting and receiving instruments, is substantially the same as that described in the letter of June 28, omitting the resistance and the enclosing box, through

which a current of air was passed to vibrate the reed, the latter being set in motion by plucking or blowing with the bellows (see the letters on pages 1613 and 1616 respectively).

We have thus far absolutely nothing in writing describing the experiments with two membrane instruments. The letter of July 1st, 1875, suggests what might be *hoped* from such experiment; the letter of July 7th, 1875, written apparently after making such experiments, is eloquently silent as to their result.

The next thing which appears historically as to Mr. Bell's invention, is his letter of August 14th, 1875, to Mr. Hubbard, which is as follows :

" On glancing back over the line of electrical experiments I recognize that the *discovery of* the magneto-electric current generated by the vibration of the armature of an electro-magnet in front of one of the poles, is the most important point yet reached. I believe that it is the key to still greater things. The effects produced, though slight in themselves, appear to me so great in proportion to their cause that I feel sure that *the future will discover means of utilizing currents obtained in this way* on actual telegraph lines. So important does it seem to me to protect the idea, that I think some steps should be taken immediately towards obtaining a caveat or patent for *the use of a magneto-electric current, whether obtained in the way stated above* (by the vibration of permanent magnets in front of electro-magnets), *or in any other way*. I should wish to protect it specially *as a means of transmitting* simultaneously musical notes differing in intensity as well as in pitch. I can see clearly that the *magneto*-electric current will not only permit of an actual copying of spoken utterance, but of the simultaneous transmission of any number of musical notes; hence messages without confusion. The more I think of it, the more I see that the *method* of making and breaking contact so many times per second is only the first stage in the development of the idea. *When we can create* a pulsatory action of a current which is the exact equivalent of the aerial impulses, we shall certainly obtain exactly similar results. Any number of sounds can travel through the same air without confusion, and any number should pass along the same wire. It should even be possible for a number of spoken messages to traverse the same circuit simultaneously, for an attentive ear can distinguish one voice from another, although a number are speaking together. Don't you think it would be well to take out a caveat for *the use of the magneto-electric current?* In its present *undeveloped state*,

it might be unwise to let Gray know anything about it, unless, indeed, we could secure the principle of it in a patent."

The language of this letter militates greatly against Bell's claim to having satisfactorily demonstrated in his own mind, by the the experiment with the two membrane instruments, the practicability of transmitting and reproducing speech by means of electricity, or the capacity of his device for accomplishing this result. It is certain that it could only have been a mental victory, for the material effort failed most signally—failed so completely that it was deemed unnecessary to record it as a part of the history of its progress. And in this very letter of August, 1875, he only makes mention of it as a possible application of the magneto-electric current. An analysis of the letter of August 14, 1875, develops not the slightest evidence of even the mental assurance that his prophecies had been realized. His experiments led him to *believe* in the possibility. His experiments did not extend beyond those of Bourseul and others, all of whom were satisfied that speech could be transmitted when the means should be devised for impressing, transmitting and reproducing acoustic vibrations. Mr. Bell professes, it is true, that *a particular medium—magneto-electric currents—may* be adequate for the purpose, and that he is persuaded they will successfully accomplish the result " when we can create a pulsatory " action of the current which is the exact equivalent of " the aerial impulses." Attention is called to the fact of the emphasis laid by Mr. Bell on the discovery of the magneto-electric current generated by the vibration of the armature. He, of course, does not mean any abstract discovery of the fact that such a current may be so generated, because that had long been common knowledge to himself and to others. The discovery to which he alludes, and which he says he made for himself at least, was that such currents were strong enough to produce audible results at the receiver, not that such

currents could be generated. His *hope* is that the future will find means to utilize currents obtained in that way, and the thing which he proposes to protect by caveat or patent is the use of such a magneto-electric current, especially as a means for transmitting simultaneously musical notes differing *in* intensity as well as pitch.

In his 95th answer he says that the allusion in that letter to the method of making and breaking the contact so many times per second refers to his method of harmonic multiple telegraphy; in which, prior to the discovery of June 2d, the transmitters had been actuated by a circuit-breaker.

Referring now to this letter of August 14, 1875, we submit to the Court whether it is the language of an inventor who had devised and used instruments which he knows or considers to be adequate for the accomplishment of such results. Are they not rather the speculations of the philospher? When, says Bell, a pulsatory action of the current which is the exact equivalent of the aerial impulses is generated by the vibration of the armature of the electro-magnet in front of one of the poles "we shall certainly obtain exactly similar results." Granted; but *how* shall this be done? He had tried all of the devices which had occurred to him, and had failed. As an abstract proposition it may have been correct, but when he attempted, by the best means known or devised by him, to solve the problem and demonstrate the truth of his reasoning, he failed; there was a flaw somewhere in his calculations when reduced to material form, which produced a different result from that expected. It can be done, he says, when somebody discovers the means and corrects such errors as have occurred in my attempt at a demonstration. I am confident it can be done, though I know not as yet how to do it—is all that this letter expresses. Believing the discovery of the magneto-electric current generated by the vibration

of the armature of an electro-magnet in front of one of its poles to be the most important point yet reached, and "the key to still greater things," he suggests that steps be at once taken to protect the idea by "obtaining a caveat or patent for the use of a *magneto-electric current*, whether obtained in the way above stated (by the vibration of permanent magnets in front of electro-magnets), *or in any other way.*" His expressed purpose was to include in such caveat or patent the use and application of the magneto-electric current, not for any specific object, but generally *in order that others might not get ahead of him.*

We now propose to show that until a period subsequent to the issue of his patent of March 7, 1876, Mr. Bell had not advanced one step in the invention of the means for transmitting articulate speech. The Court will note that up to this point his alleged discovery of the 2d. June, 1875, had been availed of directly and substantially exclusively for the perfection of his system of multiple telegraphy, and upon the theory that the magneto-currents generated in his devices for that purpose had been, by the discovery of June 2d, shown to be strong enough to produce audible results at the receiver. So far as the transmission of speech was concerned, his thoughts and devices had been limited exclusively to the method by which the magneto current should be actually generated by the action of the voice on the transmitting diaphragm. His casual thought of effecting a result by vibrating a wire through which a current was passed had been abandoned; his experiments for the purpose of utilizing for transmitting speech his conception of creating the magneto-electric currents by the action of the voice had been tried in the two membrane receiving instruments he had constructed and had resulted in complete failure. In other words, his experiments, so far as they availed of his discovery of June 2d in the line of multiple telegraphy, had proved moderate suc-

cesses; so far as they availed of the discovery in the line of transmission of speech, had proved a complete failure.

In September, 1875, while in Canada spending his vacation, Mr. Bell applied to the Hon. George Brown of Toronto, for assistance in obtaining foreign patents, and met with encouragement, and so wrote Mr. Hubbard, September 28, 1875, (page 1620 of record). These negotiations seem to have pertained to electrical inventions generally, and it is not stated that the magneto-electric principle was adverted to at that time. In the month of September, 1875, while in Canada, Mr. Bell began the rough draft of the specification which now forms part of his patent of March 7, 1876, and continued the same after his return home in October (see page 1621, *et seq*). This specification was carefully prepared and seven detached sheets of notes are introduced. Mr. Bell says, in answer to the 111-112th interrogatories, that he made others, but after search has been unable to find any others than those produced. It is in keeping with the ideas expressed in the letter of August 14th, and was undoubtedly drawn with the purpose to cover the use of the magneto-electric current, however generated. On sheet 1 (see page 1621) it is stated:

> "My present invention consists in the employment of a vibratory or undulatory current of electricity in place of a merely intermittent one; and of *a method* and apparatus for producing electrical undulations upon a line wire."

On the other side of the same sheet the page begins:

> "By inducing undulations in (upon) a continuous voltaic circuit by the motion of bodies capable of affecting a current, such as the armature of an electro-magnet, a permanent magnet, or a body through which a continuous current of electricity is passed."

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The Court will note that that statement is in pursuance of the same erroneous notion set forth in his

letter to Mr. Hubbard of July 7th, that the vibration of the armature in some way induces undulations in the voltaic current itself; whereas, as is abundantly shown in the proofs, no such effect is produced upon the voltaic current, which has no other function than that of magnetizing the cores in the electro-magnets. That sheet is accompanied by a drawing substantially like *A*, figure 5, of the patent of March 7, 1876. On sheet 2 is written :

"It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet, a current of electricity is induced in the coils of the latter, and that when it is made to recede, a current of electricity of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond in number per second to the vibrations of the magnet in polarity to the direction of motion of the permanent magnet and in intensity to the amplitude of the vibrations of the permanent magnet."

And on the same side of the same sheet there were written three claims: the first is substantially the same as the first claim in his patent of March 7, 1876; the second is in these words:

"The *method* of *inducing* (impressing) undulations in a continuous voltaic current by the vibration or motion of bodies capable of affecting the current, whether such bodies be permanent magnets or armatures of electro-magnets, or bodies through which a continuous current of electricity is passing."

The third is in these words:

"The phonautograph whereby two or more vocal or other sounds differing in pitch, loudness and *timbre* can be transmitted singly or simultaneously along a single wire, by causing electrical undulations upon the wire similar in form to the aerial vibrations accompanying such vocal or other sounds."

On sheet 3 there is the statement:

"4. The method of producing an undulatory current by the

vibration of a body through which a continuous current of elec. is passed."

On the other side of the same sheet, as follows :

"6. The method of and apparatus for transmitting simultaneously sounds differing in *timbre* as well as in pitch and in loudness. 7. The method of and apparatus for transmitting vocal utterances telegraphically, substantially as herein set forth."

On sheet 2 is written the following :

"In illustration of the method of creating a vibrat. current of elec., I shall show and describe one form of apparatus designed *to produce undulations in a continuous voltaic current.* But I wish to state here that the same effect may be produced in many other ways, all that is necessary being to influence the current by *the vibration or motion of bodies capable of affecting* the current."

On sheet 4, under the head of "Claims," three claims are made as follows :

"First. In a system of telegraphy in which the receiver is set in vibration by the passage of the electric current, the employment of vibratory or undulatory currents of electricity, as distinct from merely intermittent currents.

"Second. The *method* of impressing (inducing) undulations upon a *continuous voltaic current*, by the vibration or motion of bodies capable of affecting the current, whether such bodies be permanent magnets, armatures of electro-magnets, or bodies through which a continuous current of electricity is passing.

"Third. The phono-telegraph, whereby the exact pitch, loudness and timbre of vocal or other sounds can be transmitted telegraphically, by causing the body *by whose motion undulations are induced upon the line wire* to copy exactly the aerial vibrations accompanying said vocal or other sounds, and hence to induce upon the line wire electrical undulations similar in form to those occurring in the air."

Several things may be noted in relation to these sheets. First, the *method*, which may be supposed to refer to the transmission of speech, is clearly and definitely described in the same way as heretofore described by Mr. Bell as the method wherein the magneto current is caused or created by the voice acting

on the diaphragm. In the first set of claims it is expressed as the "method of inducing or impressing undulations." In the second set of claims practically the same words are used. In the third, in which set of claims is a claim to the instrument itself, if the instruments referred to be membrane instruments designed for use in pairs, as in the experiments tried on or after the first of July, then the claim refers to an instrument which acts upon the method or mode of operation described in the second claim—by impressing undulations upon a voltaic circuit by means of the diaphragm or reeds in front of the poles of electro-magnets and thereby creating electro-magnetic currents. Second, that taking into consideration all that Mr. Bell had accomplished, the conclusion is inevitable that in these draft specifications and claims he exceeded the legal limits of his invention. Under general language he interposes the several ideal or "devised" inventions, which, so far as his knowledge was concerned, had not been made. He had perhaps prophesied that these things could be done by the employment of magneto-electric currents; he had speculated as to the possibility of doing these things, but when he attempted to give form and substance to his theories, to solve the problem which his fancy had created, he met with no success whatever. With the exception of the "harp instrument," which was never constructed, he had tried every form of instrument yet devised by him for the transmission and reproduction of speech, but had never succeeded in accomplishing that object.

What, then, had he invented? A *theory* which he could not at that time either utilize himself or instruct others how to use. His predictions afterwards proved to be correct, but at the time he was powerless either to demonstrate the correctness of his theory or offer its benefits to the public; for he had accomplished surely no more, and indeed we submit, far less toward the realization of his dream than had Boursell and Reis

and others. Reis had transmitted words and sentences; Reis had certainly transmitted many musical sounds. Bell had failed to transmit anything beyond "a faint sound." In order, however, that others might not occupy this portion of the domain of invention, he proposed to obtain a patent, and starts drawing his specification and claims in order to secure that patent that he might shut out the field of invention to his competitors and leave to him alone the task of practically inventing the instruments which he had prophesied, or which he thought might be invented.

In December, 1875, Mr. Bell made a drawing for Mr. George Brown. The drawing is referred to in Mr. Bell's testimony on pages 1625 and 1626. The drawing itself, by accident, is not found in the Molecular Record, but is found in the Drawbaugh Record, Volune IV., Complainant's Exhibits, between pages 30 and 31. The drawing, though roughly executed, bears a most striking resemblance to the drawings annexed to the patent. There are three figures corresponding to figures 5, 6 and 7, and underneath each is written a legend. The sketch at the top of the sheet shows arrangements of battery and instrument, as in figure 6, and is thus described:

"Present form of multiple telegraph. One main battery, closed circuit, communication in both directions without induction coil. Patent not yet applied for."

The sketch in the lower left-hand corner coincides with figure 5, and the first figure with the letter of July 7, 1875, and is thus referred to:

"*Discovery that led to the above form of the multiple telegraph.*"

This undoubtedly refers to the accidental discovery of June 2d, 1875, before referred to. The remaining figure represents figure 7, with the following legend underneath:

"First attempt to transmit the human voice. The varying

pitch of the voice could be discriminated, but *not the quality*. A sort of muttering effect was perceived at the receiving end when a person talked very loudly at the other end."

This, then, is the instrument whereon the fifth claim of his patent of March 7, 1876, is founded. The pitch of the voice must have been indicated by the "muttering effect," as quality was entirely absent. Only the two instruments described by Bell as being constructed with membranes had been constructed or tried. Mr. Bell had heard nothing—Watson merely a faint sound—and the only evidence respecting the pitch being reproduced is when the membrane transmitter and the harmonic, or reed receiver, were used together, as mentioned in the letter of July 1, 1875, and prior to the construction of the second membrane instrument, and, consequently, prior to the time when the membrane was used as a receiver. A slight difference is noticed between the instruments made in June and July, 1875, and shown in exhibits, and those illustrated in the sketch and patents. The frames, straining devices for the membranes, the superior method of hinging the reed, and the means for adjusting the electro-magnets, are omitted in the sketch and patent. In place of short *tubes*, cones with diverging sides for the transmitter and converging sides for the receiver are substituted. From these drafts the specification was prepared for Mr. Hubbard to take to Washington, and after examination by Mr. Bell's patent solicitor (see page 1624), Mr. Hubbard went to Washington with it, and on the morning of January 18, 1876, Mr. Bell received from Mr. Hubbard a letter which he has lost, but the contentents of which he remembers by reference to a letter which he wrote January 18 to Mr. Hubbard's daughter, in which the following passage occurs:

"I received a nice letter from your father this morning, in which he says how well pleased he is with the new specification, and that it promises to be of great value, *if I prosecute my researches diligently*—if not, others may supplant me. He says: 'I have been

over your specification with Mr. Pollock; he is very much pleased with it, and says he does not think it will require any alteration'" (see p. 1624).

On the 19th or 20th of January Mr. Bell received from Mr. Pollock a letter in these terms:

"Herewith find applic. papers, etc., for your new improvements in telegraphy. We have left blanks for title of invention in the oath, which you can fill in. Please execute the papers as indicated in pencil, and return them to me. Very truly yours" (see p. 1624–5).

The specification was verified on the 20th January, 1876, and was filed in the Patent Office February 14, 1876, and the patent issued March 7, 1876.

The delay in the verification and the filing, Mr. Bell says, was caused by waiting for Mr. Brown to proceed in England in taking out a patent; but finally the application was filed without waiting. On the 19th February, five days after the filing of his application, Mr. Bell was notified that there was on file a caveat which conflicted with his first, fourth and fifth claims, and that his application was suspended to await the completion of the caveat application. This appears to have been the first intimation of a competitor that Mr. Bell received, although in his letter of August 14, 1875, wherein he suggested the advisability of taking out a patent or caveat for the use of the magneto-electric current, he says: "In its present undeveloped state it might be unwise to let Gray" (with whom he was then in interference on the multiple harmonic system) "know anything about it, unless, indeed, we could secure the *principle* of it in a patent." He evidently suspected that Gray might be at work on the application of the *principle* there referred to, as the paragraph referred not alone to the transmission of the vocal sounds, which is described as a possible application of the magneto-electric current, but to the *principle* underlying all this application as contained in the patent

under consideration. The caveat referred to was that filed by Gray, February 14, 1876, the same day Bell's application was filed. It was subsequently determined by the Commissioners that the caveator was not entitled to notice under the statute, and the letter of suspension to Bell was withdrawn and the patent granted.

We would here call the attention of the Court to a point much commented on by counsel for the complainant in relation to Gray's claim for priority. It is said that Gray in a letter affirmatively and distinctly disclaimed priority of invention of the speaking telephone. The letter is found in our record, page 1105; it is dated March 5, 1877, is written to Prof. Bell, and the part of it commented on is in these words:

> "Of course you have had no means of knowing what I have done in the matter of transmitting vocal sounds. When, however, you see the specification you will see that the fundamental principles are contained therein. I do not, however, claim even the credit of inventing it, as I do not believe a mere description of an idea that has never been reduced to practice, in the strict sense of the phrase, should be dignified with the name 'invention.'"

Gray's disclaimer must be taken in connection with his definition of the word "invention." If now we look at his caveat, and compare what he described with what Bell has described, we submit that Mr. Gray had gone much further in the way of clearly discovering and announcing the principles of the modern telephone than had Mr. Bell.

The caveat will be found on page 1989, with the drawing annexed; it shows what is now commonly called a "variable resistance" telephone, with a liquid transmitter; the principles upon which it operates are clearly expressed, and the object is in plain terms stated to be "the enabling persons to talk at a distance the same as if they were personally present." This invention of Mr. Gray thus clearly expressed, with the drawing showing the way in which it was worked, was not regarded by him as deserving

the name of invention, because it had not been reduced to practice, which he supposed was necessary to constitute an invention, and he had not, as yet, tried it so as to show that it was a definitely operative instrument. How strong the contrast between the views entertained by Mr. Gray as to what was an invention and those entertained by Mr. Bell, who desired to patent the use of a magneto-electric current the moment he had accidentally discovered that it was capable of so operating as to produce an audible result at the receiver!

Bearing now in mind that between July and the date of his patent, Mr. Bell had made no experiments, we would call attention to what he did immediately subsequent to his patent. In answer to the 132d Interrogatory he says that after the grant of that patent he continued his study and *experiments* on the subject of transmitting articulate speech or other sounds, for the purpose of introducing his invention into public use. It would thus seem that, according to his own views at that time, it was not yet fit for introduction into public use. Undoubtedly continued experiments and study were necessary, inasmuch as he had only so far described and invented an instrument, or, as Mr. Bell calls it himself, "an electrical diagram" which experience taught him was, for some reason at that time not understood, inadequate for the purpose (page 1695, question 395).

In his preliminary statement in the interference cases Mr. Bell tells us the result of one of the earliest of his subsequent experiments. In it (Record, page 2083) he says:

"I ought to state *that I did not, before the filing of my application, construct the devices described in my specification for varying the resistance of the voltaic circuit as means for producing an undulatory current.* I was in Washington the first two days in March, and immediately on my return I constructed an apparatus having a wire attached to a stretched membrane, dipping into a vessel containing water, forming part of a circuit, the resistance of the circuit being varied by the vibration of the membrane, which caused the wire to dip more or

less deeply into the liquid. On the 10th of March Mr. Watson and myself tried this apparatus as a transmitter, using the steel spring armature depicted in my patent as a receiver, and obtained intelligible articulation. I exhibited an instrument constructed in this way at the Centennial Exhibition in June, 1876, before Sir William Thompson and other judges of his department."

It is not easy to see that anything in this description is lacking to correctly and completely describe the device described in Gray's caveat above referred to. It will be noted that this is the first time when Mr. Bell pretends to have obtained "intelligible articulation," and this is three days after the issue of his patent, and with a Gray transmitter and a Bell multiple telegraph receiver, or Fig. 5 and 6 receiver, and without any part of Fig. 7 of his patent. Mr. Watson (p. 1853) testifies that prior to March 10, 1876, he had no recollection of ever having heard more than a sound through the telephone—that is, the sound of Mr. Bell's voice. In answer to question 146 (p. 1854), he says that he has no recollection of having understood anything that was said through the telephone prior to March 10, 1876. On pages 1854 1855, by the aid of a diagram there shown, he describes the water transmitter through which on the 10th of March he first heard intelligible articulation. By the language of his preliminary statement one would infer that Mr. Bell meant it to be understood that his patent of March 7, 1876, had described devices for varying the resistance of a voltaic circuit as means for producing an undulatory current, with reference to figure 7, and for the purpose of creating electrical undulations on the line wire which should correspond in their form with the aerial vibrations which caused the vibration of the membrane. An inspection of the patent will show that there is not the faintest suggestion anywhere through it of any other device for producing the results ascribed to figure 7 ; nor is there a suggestion that the results ascribed to figure 7 could be produced in any of the

ways suggested in the specification other than in that shown by the device of figure 7; nor had Mr. Bell's previous studies or experiments shown or tended to show that at any time prior to the issue of the patent of March 7, 1876, he had conceived, disclosed, experimented upon, tested or contemplated so doing, any form or system of articulating telephone other than the magneto as disclosed in figure 7 of his patent, with the single possible exception of the abandoned and discarded idea of the vibrating wire.

By the language of the preliminary statement, page 2083, it appears that the instrument and experiment there referred to consisted of a reed receiver; but Bell's testimony and the history of his previous experiments show that it was upon a membrane receiver that he had relied for producing audible effects. The fact, however, seems to be that the use of such membrane receiver had been of so little practical or suggested value to him that when he tried this water transmitter and obtained from it intelligible articulation for the first time, it was in connection with and by means of a simple reed receiver. On page 1851, answer 125, Mr. Watson describes the receiver used on the occasion of the experiment on March 10, 1876. He says, in one room an instrument similar to Exhibit 29—Centennial Liquid Transmitter was connected to this wire, and at the other end was what is known as a harmonic receiver, which is another phrase for multiple telegraph receiver. In the next answer he describes the harmonic receiver in detail. It consisted of an L-shaped piece of iron the legs of which were about two inches long, having on one end the coil and core of an electromagnet and clamped to the other a piece of steel clock spring which projected over and near to the end of the coil; and he adds that the instrument was precisely similar to the instrument shown at the end of the circuit in figure 5 of Bell's patent of March 7, 1876, with

the exception that the figure referred to was not mounted on a base.

The question is, then, when did the idea of this liquid transmitter originate? No substantial or tangible trace of such an instrument is to be found in the patent. The fact that the movement of an electrode in a liquid of relatively high resistance would vary the current passing over the line, as stated in the patent, was well known in the art. It seems perfectly evident from the testimony and surrounding circumstances that if the idea and development of a water telephone was original with Bell at all it was conceived at some period between the 14th of February and the 10th of May, 1876, and after being made aware of Gray's caveat, and that it referred to the vibrating of a wire in water.

When Mr. Bell was notified of his application being suspended on account of an interfering caveat he came to Washington to inquire into the matter. He says that he was not allowed to see the caveat, but was given to understand that it related to the vibration of a wire in a liquid for executing or carrying out the invention described in his fifth claim (see p. 1653). Subsequent to that the experiments of March 10th were made. On the 10th of May, 1876, in a paper read before the American Academy of Arts and Sciences (see page 1729), Mr. Bell described the liquid transmitter. The receiver is not there described. Subsequent to his experiment with the liquid transmitter, on the 10th of March, Mr. Bell modified his magneto instrument by disconnecting the diaphragm from the magnet, and by gluing a piece of clock spring about the size and shape of his thumb-nail to the centre of the diaphragm (see page 1637, Answer 180). The statement of this experiment is much more detailed in cross-examination (pages 1723–24 *et seq.*). Mr. Bell's attention is there called to an extract from his London lecture, in which he had stated what he had presumed would be the effect of speaking into a device

substantially like that of figure 7 in the patent, and in which he added:

"The results, however, were unsatisfactory and discouraging. My friend, Mr. Thomas R. Watson, who assisted me, in his first experiment declared that he heard a faint sound proceed from the telephone at his end of the circuit; but I was unable to verify his assertion. After many experiments attended by the same only partially successful results, I determined to reduce the size and weight of the spring as much as possible. For this purpose I glued a piece of clock spring, about the size and shape of my thumb nail, firmly to the center of the diaphragm, and added (had) a similar instrument at the other end. We were then enabled to obtain distinctly audible effects."

Mr. Watson, in the extracted testimony, was then asked whether the instrument there referred to by Mr. Bell in the London lecture, as having a piece of clock spring glued to the diaphragm, was not the same instrument to which Mr. Watson had referred in his testimony as having been made in March or April, 1876, and at least after March 10th, and through which for the first time they had understood words transmitted through a magneto transmitter, and had answered that he did not actually know, but was inclined to think so. Mr. Bell being asked whether his recollection agrees with Mr. Watson, replied that it did (Questions 472–473, pages 1722–1724).

Thus we have seen that up to the date of his patent Mr. Bell had invented a magneto-electric machine for the transmission of sound. He had not invented or described any other process than the one denominated the magneto-electric. He had had in his mind the use of this magneto-electric machine for the transmission of speech and had failed to make any effort practically to put the same in shape or use because of the conviction remaining in his mind that the magneto-electric current would be too feeble for practical use. The experiment of June 2d, 1875, had, to a more or less extent, disabused his mind of that notion

and he had thereafter set to himself the task of inventing a machine or apparatus which might carry into effect the properties which he now supposed to exist in the magneto current. The Court will see that this problem was sufficiently difficult; it was essential to construct a device which should take up all the vibrations of the air produced by the act of speaking, and which should transmute the same into electrical action, so as in turn to affect a diaphragm at the receiving end; at least, it was required that the device should transmit enough of the air vibrations taken up by the transmitter to produce the practical result at the receiver. Various difficulties were in the way; among others was one which he seems to have appreciated, to wit: the difficulty of preventing the transmitter from transmitting its own vibrations, or vibrations caused or flowing from its own normal rate of vibration, while at the same time he compelled it to take up and transmit the forced vibrations given to it by the air. Up to the date of his patent, as we have seen, he had completely failed to do this thing. Not only that, but he himself and his witnesses state that the drawing, figure 7 in the patent, was not intended to show or illustrate a concrete practical machine or device, but that it was simply an electrical diagram to represent the *method* of electrical action.

If that be true it shows two things. First, that the *method* referred to by him and in his mind was not the broad *method* now claimed in the terms of the fifth claim without reference to the specification, that is, transmitting by causing electrical undulations similar in form to that of the aerial undulations which caused them; but, on the contrary, is the *method* of producing electrical undulations by the magneto-electric device suggested by him and wherein the magneto current is the creature of and caused by the voice which speaks or utters itself to it, and in which, consequently, the current itself must be, to a great extent, a tran-

script of the vibrations caused by the voice. Second, That the patent shows no apparatus or means or way for carrying the method into effect, because Fig. 7 cannot be reduced to a mere electrical diagram in order to escape its insufficiencies as a machine, and at the same time be regarded as a machine shown to carry the method into effect.

Following the example of the Examiner in Interferences, let us now, and substantially in the words of such Examiner, examine Mr. Bell's patent of March 7, 1876, as a part of the history of his invention, and treating it as documentary evidence. As appears from Mr. Bell's letter of August 14, 1875, to Mr. Hubbard, and from other evidence in the case, Mr. Bell's design and purpose in filing this application were to secure a patent for the use of the magneto-electric current however obtained and applied. He desired in its undeveloped condition to secure the *principle*, lest others should precede him. Pursuing this idea, a specification was drafted and negotiations entered into for obtaining foreign patents as well as American. This specification was prepared to cover the principle of the use of the magneto-electric current in telegraphy, and with that end in view every effort was made to express all conceivable ways of generating and applying that power. Possible and probable applications were sought to be obtained; if the principle could be secured in a patent all applications thereof would be subservient; and this he well knew. That the scheme was regarded as more or less visionary is indicated by the letter to Mr. Hubbard of January 18, 1876, after the specification had been prepared. "It promises to be of great "value *if I prosecute my researches diligently;* if not, "*others may supplant me*"—is Bell's interpretation of Hubbard's warning. Looking at the patent not as a grant, but as a part of these transactions, we find it strictly in accordance with the views above expressed. The pulsatory current mentioned in the letters of July

7 and August 14, becomes in the specification "vibratory or undulatory." Its characteristics are pointed out at length, and the advantages to be gained over the intermittent current which he had previously made use of set forth. The invention is denominated :

"An improvement in Telegraphy," and is said to consist "in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of, and apparatus for producing undulations upon the line wire."

The use of the magneto-electric current, whether obtained by the vibration of permanent magnets in front of electro-magnets or in any other way, constituting the "principle" to be secured, as mentioned in the letter of August 14, is now presented as the employment of "a vibratory or undulatory current," and the method or apparatus are only such as have been tested and heretofore described. While the principle or mode of operation is enlarged upon and minutely described, not a single feature of the apparatus for carrying it out is changed. The instruments referred to and illustrated in the letter of July 7th are described as typifying the inventions; and that is the improvement in telegraphy which consists in the employment of undulatory, as contradistinguished from intermittent, currents. Two or more electro-magnets, with tuned reeds for armatures, are placed in a circuit with a battery. When one or more of the reeds are set in motion "by the wind" (referred to in letter of June 28) or otherwise, the reeds normally in unison therewith will respond. *As an alternative mode* for imparting motion to the armature, he describes the membrane instruments made in June and July ; the tuned reeds he had tested and found to produce perceptible results ; the membrane apparatus he had tried with the most imperfect and equivocal results. Both were based upon the same principle, hence both were expected to produce similar

results; in theory they were operative, in practice inoperative. The reeds of the transmitter when set in motion produced musical notes ; the same vibrations were supposed to induce corresponding undulatory currents; these currents operating upon the reeds of the receiver, having the same normal rate of vibration as the transmitter, set them in motion, and the same notes were produced at the other end of the line. This was the only demonstration of the principle that he had concluded. It was designed for telegraphic purposes and constitutes the only mode of applying the principle disclosed or referred to as such in his specification. *Having* succeeded in this, he attempted to adapt the same principle to the transmission of speech. If the vibrations of the reeds were transformed into undulatory currents *which* were capable of producing the same tone at a distance, why should not the aerial vibrations be transformed into undulatory currents and be reproduced at the receiving instrument? For the purpose of testing this application of the principle he constructed in June, 1875, his membrane transmitter designed to produce undulatory currents corresponding to the aerial vibrations. It was connected in circuit with the harmonic or reed receiver, and not with the membrane receiver, and at that time he had not constructed any membrane receiver. Upon trying this membrane transmitter and reed receiver they failed to accomplish the result. After experimenting further with the reed instruments results were obtained which induced him to construct another membrane instrument for use with the first. This, however, was not done until a month had elapsed from the trial of the first experiment. With this instrument—that is, the membrane transmitter and a membrane receiver—slightly improved results were obtained—that is to say, a sound was heard; but the object of the experiment—the transmission and reproduction of speech—was not even

imperfectly obtained. The legend written upon the Toronto drawing about the time this specification was drafted proves beyond question the failure of this experiment. As applied to this specification it shows that the principle had to a certain extent been carried out by the membrane instrument—that the armature could be set in motion by the voice, and undulatory currents be produced thereby which would affect a receiver; but the *timbre*, the essential characteristic of speech, had not been reproduced. Lest others might get ahead of him and make available this mode of vibrating the armature for producing undulatory currents, he set it forth as an alternative method for that already described and failed to insert in the specification the many statements which were included in the drafts first prepared by him, which distinctly and emphatically and in terms refer to the production of articulate speech.

If, therefore, we examine that portion of the specification having reference to the membrane instrument in connection with the description which precedes it and the results actually obtained by Bell in his experiments, the true meaning will be apparent. The invention being an improvement in telegraphy consists in the employment of vibratory or undulatory currents of electricity. But one form of apparatus is referred to as illustrating this invention.

"In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect."

Then follows the description of the tuned reed apparatus, and it is stated that "the armature (reed) C can be set in vibration in a variety of ways, one of which is by wind, and in vibrating it produces a musical tone of a certain definite pitch." The undulatory current produced by this vibration passes through the coil of the receiving instrument and causes its reed or

armature to vibrate "when the armatures of the two "instruments are normally in unison with one another, "but the armature (of the receiver) is unaffected by the "passage of the undulatory current when the pitches "of the two instruments are different." He then proceeds to describe the multiple-telegraph arrangements of such instruments, each receiver to respond to its particular transmitter and to no other.

"The duration of the sound may be used to indicate the dot and dash of the Morse alphabet, and thus a telegraphic despatch may be indicated by alternately interrupting and renewing the sound;" and the same is applicable to the multiple arrangement. "I desire here to remark that there are other uses to which this instrument may be put, such as the simultaneous transmission of musical notes differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind."

As to loudness and pitch he has reference to the difference in the amplitude of motion given to the reeds and their normal rate of vibration; but with respect to "noises or sounds of any kind" the record affords no evidence.

The Court will note that the passage above quoted precedes any reference whatever to figure 7. Figure 5 of the drawing illustates the reed and figure 7 the membrane instruments.

"One of the ways in which the armature C, figure 5, may be set in vibration has been stated above to be by wind; another mode is shown in figures 7 whereby motion can be imparted to the armature by the human voice or by means of a musical instrument."

He does not state this as another application of the principle of magneto-electric or undulatory currents, nor as another effect or result to be obtained through the use of the undulatory currents, but *another mode of vibrating the armature* as a substitute for wind and for the same purpose. It is an alternative method of vibrating the armature and not a new or different application of the principle.

In looking at the drawings, the Court will see that figure 7 is substantially identical with figure 5 with a membrane fastened to the free end of the vibrating reed of figure 5. Looking at the drawing in that way, the Court will see the absolute propriety of the language of the patent in describing figure 7 as another mode whereby motion can be imparted to the armature. In speaking, however, of this instrument the patent says:

> "When the sound is uttered in the cone, the membrane is set in vibration; the armature is forced to partake of the motion, and thus electrical undulations are created upon the circuit. These undulations are similar in form to the air vibrations caused by the sound; that is, they are represented graphically by similar curves, the undulatory current passing through the electro-magnet (of the receiver) influences its armature to copy the motions of the armature (of the transmitter); a similar sound to that uttered into the transmitter is then heard to proceed from the receiver."

This was Mr. Bell's theory of the operation of the device. He may have designed the device for transforming speech into electrical undulations of similar form and their reconversion into aerial vibrations, but he did not say so, and if so designed, it failed. "The varying pitch of the "voice could be discriminated, but not the quality; "a sort of mut- "tering effect was perceived at the receiving end when a person talked very loud at the other end" is Bell's formal description by the legend under his Toronto drawing of the best result that had been attained. This is the extent to which the motions of the armature were copied at the receiver, and to this degree only were the sounds heard at the receiving end similar to those uttered into the transmitter. Not only were the instruments described, when actually tried, incapable of performing the functions which it is claimed his language should be so construed as to ascribe to them, but as his knowledge did not extend beyond this embodiment of his ideas, he was absolutely

unable, for want of the proper devices, to produce any such results as the reproduction of sounds similar to those uttered into the transmitter. His assumed knowledge did not extend beyond the "possible" or the "probable." As another, though imperfect, mode of setting in vibration the armature, it may properly have been considered the equivalent of the reed operated by wind; that it was so intended and considered by him seems quite clear from various subsequent documents and statements from him. In his subsequent patent and in his English patent the use of this figure 7 for purposes of multiple telegraphy is clearly indicated. This will be alluded to more fully in another place; it is sufficient here to refer to page 1757, answer 591, where Mr. Bell says that he experimented in Canada with telephones made with a triple mouthpiece, so that three different persons could speak or sing to the same membrane telephone, and upon listening at the receiver he was able to distinguish one voice from another and one pitch from another, even when the three persons at the transmitting end spoke or sang simultaneously. Evidence on this point is also found on pages 1661–2–3–4 and 1697, and on pages 1705–6–7–8–9–10 and 1762 to 1765. Beyond this use as a multiple telegraph of figure 7 and for the transmission and reproduction of speech, it was an abortive and unsuccessful attempt to demonstrate a theory which subsequent events proved to have been correct, and which, had the instrumentalities been adequate and the effort sufficiently determined, would undoubtedly have been productive of entirely different results from those obtained. Although it may be, as he states in this specification, that the instruments described will convert "the air vibrations caused by the sound" uttered into electrical undulations, and these in turn into aerial vibrations representing a similar sound (though, singularly enough, articulate speech is not specifically mentioned, though

Mr. Bell was thoroughly impressed with its importance, and considered it the most important, if not exclusively, the object sought), yet notwithstanding such statement, it does not prove that such was their action, or that he had succeeded in accomplishing this result. He does not say in so many words that the apparatus referred to will transmit and reproduce speech, for he had found the contrary to be the case; but under the general title "similar sounds" he classed the "mutterings." To be sure, he alleges that the undulations set up in the line are "similar in form to the air vibrations caused by the sound," and as the armature of the receiver is to copy the motions of the armature of the transmitter, a "similar sound" is heard; but inasmuch as the sounds heard were similar only in respect to pitch and amplitude, and this remotely, it is not to be presumed that he means similar in all respects, particularly as to the *timbre*,—which in his experiments with this instrument was entirely lacking.

In the single paragraph devoted to this alternative mode of vibrating the armature, the action of the instrument is thus set forth:

"A sound being uttered, the membrane is set in vibration; the armature is forced to partake of the vibration and electrical undulations are created upon the circuit."

It had been previously stated that the character of the undulatory current was dependent upon the motion of the armature.

"When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coil of the electro-magnet, the undulations of which correspond in rapidity of succession to the vibrations of the magnet in polarity to the direction of its motion, and in intensity to the amplitude of its vibration."

Again:

"Electrical undulations induced by the vibrations of a body capable of inductive action can be represented graphically without error by the same sinusoidal curve which expresses the vibration of the inducing body itself and the effect of its vibration upon the air; for, as above stated, the rate of oscillation in the electric current corresponds to the rate of vibration of the inducing body—that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration—that is, the loudness of the sound."

So far as the description extends, two characteristics of sound are said to be represented by the undulatory current—pitch and loudness; but nothing is said of *timbre*, which Bell well knew indicated something more. It will be noted also that the illustration in figures 1, 2, 3 and 4 of the drawings was only of simple sounds, and of the combination of simple sounds. There was thus nothing in the patent prior to the paragraph with respect to figure 7 to in any way indicate that any kind of undulation was referred to or intended to be represented graphically other than the undulations caused by a simple sound. No reference is anywhere made to overtones, or to any of the peculiar vibrations which characterize articulate speech. The variations in the character of the undulatory current and the sinusoidal curves representing it are said to be due to changes in the motions of the armature. Hence the motions of the armature determine the nature of the undulations. The only variations in the motions of the armature which are mentioned in this connection have reference to rate and amplitude, whereby the graphically-expressed form of the undulatory current is made to vary with the pitch and loudness. The membrane instruments as representing another mode of vibrating the armature are not said to have any *further* capacity for changing the form of the undulations. The vibrations given to the armature were supposed to vary with the sound uttered as

to rate and amplitude, for nothing more had been presumed or accomplished. Hence, when it is stated that these "undulations are similar in form to the air vibrations caused by the sound—that is, they are represented graphically by similar curves," Mr. Bell means similar as to pitch and loudness, rate and amplitude, *for no other form has been mentioned as incident to sound vibrations, sinusoidal curves or undulatory currents.*

This feature of different tones and pitch is referred to in the letter of June 2, 1875, but quality is not mentioned.

The fact that sound vibrations *have other* characteristics than those stated does not necessarily imply that he intended or understood that *they* would be copied: on the contrary, the fact that he had endeavored to induce this additional form of vibration and to impress upon the undulatory current the characteristic of *timbre*, and had failed; and the further fact that he does not even allege that this operation is performed by the device originally intended for that purpose; and the fact that if he had so intended and was honest in such intention, he, like any other man, would undoubtedly have stated in his patent that he had solved the problem of the transmission of speech, and not have left it to be vaguely inferred by enlarging the use of scientific terms, prove conclusively that he did not presume to describe the membrane instrument as other than an alternative mode of vibrating an armature for the same purpose as the reed instruments and as illustrating the same principle.

It is true, that notwithstanding all this, the Examiner in Interferences awarded to Mr. Bell priority of invention as of the date of his patent 174,465. He did it, however, not because *he* thought that the invention of the telephone was described in that patent, but because that patent had been construed by the Courts below in some of these cases as covering the invention of the speaking telephone, and the Examiner, very properly,

felt bound to follow the construction given by the Courts.

A further illustration of the quite vague ideas Mr. Bell had at the date of his patent with respect to his instrument, figure 7, is shown in his testimony with regard to the use of a permanent magnet, as shown in his second patent. On pages 1630 and 1631 will be found, first, a letter from Mr. Bell, wherein he speaks of his great discovery, that he could operate a telephone line having a large resistance, equivalent to that of 325 miles of well-insulated telegraph wire, with a battery consisting of a single cell. That discovery made him sure that by substituting a permanent magnet he could work it without a battery at all. In answer to question 147, he said that his original idea in the summer of 1874 was to transmit sound by means of magneto-electric currents without a battery, and from the time of his first conception of the speaking telephone he had the belief that the apparatus could be operated by substituting a permanent magnet for the soft iron core of the electro-magnet. Being then asked why he used a battery in his speaking telephone, he answered:

"Because the effects obtained were much more powerful with a battery than without, and because I had the idea that in operating the instrument through any considerable resistance, as upon a real telephone line the battery would produce the most practically useful results."

Now, inasmuch as Mr. Bell's early experiments, particularly about June, 1875, had been made with the battery cut off and with no other power in the magnet than that of residual magnetism, it is easy to see where he obtained the notion that the effects were more powerful with a battery than without. If he had waited a little longer after the cutting out of the battery, there would have been no effects at all. He apparently was not then aware of what is now, by all the experts in the case on both sides stated to be the fact,

that the voltaic current has absolutely no other function in a magneto telephone than that of magnetizing the cores of the magnet, and has no effect whatever upon the loudness of sound produced at the receiver. That effect would be caused only by the amplitude of the vibrations of the transmitting armature. This same notion of Mr. Bell is shown in various parts of the record. In his letter of July 7, 1875, to Mr. Hubbard he suggests that a pulsatory action may be induced in the voltaic current itself (pages 1616–1617). In his original draft of the specification for the patent (pages 1621–2) he speaks of inducing undulations on a continuous voltaic current. This very patent of March 7th states that undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, and states it, too, with the apparent idea that the strength of the voltaic current is thereby availed of. This apparent error of Mr. Bell as to the actual function of the battery in the devices described by him has been commented upon by electrical writers. Prescott, in his work on the Speaking Telephone, Edition of 1878, page 19, refers to it in these words:

"During the ensuing time some important changes in the telephone were effected whereby its articulating properties were greatly improved. Prof. A. E. Dolbear, of Tuft's College, observing that the actual function of the battery current with which the line was charged in Bell's *method* had simply the effect of polarizing the soft iron cores of the transmitting and receiving instruments, or of converting them into permanent magnets, and that the mere passage of a constant voltaic current through the line had nothing to do with the results, conceived the idea of maintaining the cores in a permanently magnetized or polarized state by the inductive influence of a permanent magnet instead of by a voltaic current."

True, in a subsequent edition of his work, that of 1884, on page 19, when writing under other influences, Mr. Prescott ascribed this observation to Prof. Bell. He uses substantially the same language, except that

he attributes the observation to Prof. Bell. We quote his language in the second edition :

"During the ensuing time some important changes in the telephone were effected whereby its articulating properties were greatly improved. Prof. Bell, the inventor, having observed that the actual function of the battery current, with which the line was electrically charged, had simply the effect of polarizing the soft iron cores of the transmitting and receiving instruments, or of converting them into permanent magnets, and that the mere passage of the constant voltaic current through (over) the line had nothing to do with the result, conceived the idea of maintaining the cores in a permanently magnetized or polarized state by the inductive influence of a permanent magnet instead of by a voltaic current."

Whether Mr. Prescott was right in his first or in his second edition is of no importance; it shows that the construction put by electrical writers upon the patent and published descriptions of Mr. Bell of his invention is that he had theretofore claimed and supposed that he was effecting an undulation in the voltaic current and that such undulations did work ; and that he or Dolbear, or somebody, subsequently discovered that the only function of the battery current was to magnetize the cores of the magnet, and that the battery current did no work whatever. Subsequently Mr. Bell seems to have made sundry other experiments, especially those at or about the time of the Centennial Exhibition. They were (with the instruments he then employed, and which are materially different from the devices shown in figure 7) moderately successful. No sustained conversation could be carried on ; the effect was generally inaudible, but sentences and parts of sentences were transmitted—in Mr. Bell's language—"occasionally with startling distinctness, so that it was difficult to realize that the person was not standing in his immediate proximity." How little, however, the telephone was then clearly and practically understood is evident from the fact that Sir William Thomson, whom complainant's counsel never tire of describing as

the ablest electrician in the world, being presented with a pair of telephones by Mr. Bell, took them home with him to England, and in attempting to exhibit them in a lecture was unable to operate them, owing to the fact, as suggested, that he tilted the top of the cylindrical receiver up at an angle, and thus removed it so far from the pole of the magnet that the magnet was without effect upon it and no aerial vibrations were produced. Singularly enough, it was because of this very inability of Sir William Thomson to exhibit the instrument that Bell succeeded in his English litigation on his patent; for if Sir William Thompson had succeeded in his attempt to show the instrument, it would have been such a publication under the English law as would have defeated Mr. Bell's English patent (see also testimony of Prof. Brackett, Record, page 482).

Looking back now at the history of Mr. Bell's invention up to the time of the first patent of March 7, 1876, we submit:

First.

That his patent is for a multiple-telegraph or for a singing telegraph or telephone for multiple-telegraph purposes.

In his 374th answer, Mr. Bell says that he had in view the possibility of using stretched membranes in multiple-telegraph apparatus of some kind; but he adds that it was never intended for this use, although it might be possible to make some application of the kind; and on page 1692 he says that the stretched membrane would vibrate too freely for purposes of multiple-telegraphy. But in answer to question 382, he says:

"It is true that a membrane telephone can be used for the purposes of transmitting a musical tone in the manner described above; it is true that it can be used for the purpose of receiving a

musical tone; but the effects produced, whether the instrument is used as a transmitter or receiver in transmitting and receiving musical tones are so much inferior to the effects produced with tuned instruments like those shown in figures 5 and 6, that practically for the purposes of multiple-telegraphy, the membrane telephones are by no means the equivalent of tuned reeds."

And on page 1694 his 388th answer is this:

"I meant to convey the idea in my previous answers that while it might be possible to use the apparatus shown in figure 7 for the purposes of multiple-telegraphy, it was not nearly so well adapted for that purpose as the tuned instruments shown in figures 5 and 6."

And he adds that while in 1875 and 1876 he recognized the possibility of using the apparatus for the purpose inquired about (that is, for multiple-telegraphy), he did not contemplate its employment in multiple-telegraphy.

In this testimony, it is apparent that Mr. Bell is confounding his knownledge and opinions at the date of testifying with his knowledge and opinion at the date of the patent.

The knowledge to which he testifies as to the comparative superiority of the reed or membrane for purposes of mutiple-telegraphy or speech is that acquired subsequently to the patent, for prior thereto his experiments had shown him no sufficient effect of the membrane to allow of the formation of an opinion as to its having any different mode of operation from the reed, and so far as his theoretical or scientific opinion was concerned, he thought that the mode of operation of the two were alike.

In his preliminary statement, p. 2078, he says that after talking with Prof. Henry he was discouraged as to obtaining from stretched membrane the results which he had hoped. "I remembered that the impression left upon my mind was that each stretched

membrane would *have a rate of vibration peculiar to itself.*"

Now that was the very peculiarity of the reeds.

The peculiarity too that was *sought for* by tuning the reeds or selecting them according to their rate of vibration.

It was doubtless also with reference to this very assumption of a rate of vibration in the membrane peculiar to itself that Mr. Bell described Fig. 7 as "another mode whereby motion may be imparted to the armature," he supposing that the membranes in Fig. 7, like the reeds in Figs. 5 and 6, had a rate of vibration peculiar to themselves.

In the 400th question, which quotes certain parts of the fourth plan of the English Provisional Specification, Mr. Bell was asked whether the description there given was not a description of the application to the purposes of multiple-telegraphy of the inventions which were shown in Figs. 5, 6 and 7 of the patent of March 7, 1876. The answer is in these words:

"It is in part, but in part only. It is a description of the application to the purposes of multiple-telegraphy of the apparatus shown in Fig. 7 of my March 7, 1876, patent, and the modification of it, but especially kept distinct from instruments like those shown in Figs. 5 and 6 of that patent.

Mr. Bell adds a further quotation from the English specification which states that the fourth plan is also adapted for the entire new use of transmitting intelligibly the exact sounds of articulate speech.

It will be seen from the quotation above referred to in the answer of Mr. Bell that the English patent describes and refers to the old use of Fig. 7, for multiple-telegraph purposes, and then (he) adds that it may also be used for the "entire new use of transmitting intelligibly the exact sounds of articulate speech." By cross-question 413, page 1705, Mr. Bell was asked if, as he had stated in answer to the 338th question, that

he did not contemplate the employment of Fig. 7 for multiple-telegraphy, why he inserted in his English Provisional Specification, filed December 9, 1876, a specific description of the application of that apparatus in multiple-telegraphy, and why he inserted in his United States patent of January 30, 1877, a specific description of the use in multiple-telegraphy of his telephone instruments with directions how to employ them in transmitting by the Morse alphabet. He answers as follows:

"In my answer to cross-question 338 referred to I stated that, although I did not contemplate the employment of the apparatus shown in Fig. 7 of my March 7, 1876, patent for the purpose of multiple-telegraphy, as it was *not so well* adapted for this purpose as the tuned instrument shown in Figs. 5 and 6, still I recognized in 1875 and 1876 the possibility of using the apparatus for the purpose inquired about. The specification of my March 7, 1876, patent was prepared by myself alone; whereas my English provisional specification and my United States patent of January 30, 1877, were prepared with the assistance of counsel skilled in patent law, and my impression is that it was considered advisable to state in the specification all the uses to which the instrument could possibly be put. Quite independently of this the sounds produced with my improved telephone, shown in the United States patent of January 30, 1877, and also described in the English Provisional Specification, were so much superior in loudness to those produced by the membrane telephone shown in my March 7, 1876, patent, that there really would be little difficulty in persons with skilled ears using the telephones for the purposes of multiple-telegraphy in the manner described in the specification referred to."

This answer invites the comment that for long after the date of the March 7, 1876, patent, figure 7, so far as Mr. Bell knew, was absolutely worthless for anything unless multiple-telegraphy; nothing more had been heard through it than a faint sound; approach to articulate speech there had been none. If Mr. Bell had at that time supposed that the device of figure 7 was good for anything it must have been for the transmission of some kind of signal adapted to multiple-telegraphy, and for nothing else. In addition to that, it will be

remembered that Mr. Bell had quite as much and absolutely the same professional aid in preparing his specifications for the March 7, 1876 patent, as for the subsequent one. He had drawn those specifications himself; he had forwarded them to his counsel, Mr. Pollock, in Washington, for examination, and they had been returned to him by his counsel and verified by Mr. Bell. That his counsel did not deem it necessary in any respect to alter the specification is simply a tribute to the professional skill of Mr. Bell, but in no way detracts from the force of the fact that he had consulted his counsel and was as much aided by such counsel in approving what Mr. Bell had already done in respect to that patent, as he was by suggestions of counsel for alterations in the specifications for the subsequent patents. It would seem, also, altogether probable that in sending on his specifications for the patent of March 7, 1876, to his counsel, Mr. Bell did not tell them anything about a speaking telephone, or give them to understand that his figure 7 was intended for anything else than as "another mode" for vibrating the armature of figures 5 and 6, and for the same purpose intended with respect to figures 5 and 6. For, in answer to question 425, Mr. Bell says: "My impression is that "my counsel were dissatisfied with the meagreness of "my description of the speaking telephone in my pat-"ent of March 7, 1876," and desired to supplement this by fully describing and claiming in his patent for January 30, 1877, whatever was not specifically described and claimed in the former patent. It is not to be wondered at that his counsel were dissatisfied with the meagreness of that description, if that description were intended to describe the speaking telephone; there is surely no living man, who, if called upon to-day, would not express a similar surprise that, if Mr. Bell had then really invented and intended to describe the speaking telephone, he did not use language that would have made him much more readily and easily understood.

On page 1757, as we have before said, Mr. Bell states that in Canada he had made experiments with reference to figure 7 for purposes of multiple-telegraphy, and had had a triple mouthpiece made for one of the instruments. Of course, the making of a triple mouthpiece must have contemplated that the instrument might have been used with but one large mouthpiece or without any mouthpiece. Mr. Bell himself never made or caused to be made any mouthpiece for figure 7 prior to the filing of his specification for the March 7th patent. The subsequent making of triple mouthpieces can be but a continuation of his idea theretofore existing for the use of figure 7 for purposes of multiple telegraphy.

Other and a different kind of evidence on that point may be found by reference to the publications of Mr. Bell.

In his patent No. 186,787, January 30, 1877, Mr. Bell refers to the patent of March 7, 1876, and says that in this last patent he has shown and described a method of and apparatus for producing musical tones by the action of undulatory currents of electricity, whereby a number of telegraphic signals can be sent simultaneously over the same circuit in either or both directions, and a single battery to be used for the whole circuit. He then goes on to show that in that Patent No. 174,465 and prior patents signals are transmitted simultaneously along a single wire by the employment of transmitting instruments, each of which occasions a succession of electrical impulses differing in rate from the others, and are received without confusion by means of receiving instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting instruments; that a separate instrument was, therefore, employed for every pitch, each instrument being capable of transmitting or receiving but a single note, and thus as many separate instruments were required as there were messages or

musical notes to be transmitted. This, according to his then knowledge, included a membrane. He then states that his invention as described in the patent of January 30, 1877, has for its object, first, the transmission simultaneously of two or more musical notes or telegraphic signals along a single wire in either or both directions with a single battery for the whole circuit without the use of as many instruments as there are musical notes or telegraphic signals to be transmitted; second, the electrical transmission by the same means of articulate speech and sound of every kind, whether musical or not; third, the electrical transmission of musical tones, articulate speech and sounds of every kind without the necessity of using a voltaic battery.

Is it not remarkable that if the patent of March 7, 1876, had been intended, or was drawn with the object of transmitting articulate speech, or for showing the method or device available for such purpose, that it not only should not have been mentioned in the patent, but that in the subsequent patent Mr. Bell should state that his then invention had for its object (Second), the electrical transmission by the same means of articulate speech? Is it not also curious that he should have failed anywhere in the patent No. 186,787, to state that patent No. 174,465 had for its object, or intended to use figure 7 therein described for any other use or purpose than as an alternative mode of vibrating the armature for the purpose of multiple telegraphy? It is true that in patent No. 186,787 he says:

"In my patent No. 174,465, of March 7, 1876, I have shown as one form of transmitting instrument a stretched membrane to which the armature of an electro-magnet is attached, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument, or by sounds produced in any way. In accordance with my present invention, I substitute for the membrane and armature shown in the transmitting and receiving instrument alluded to above, a plate of iron or steel capable of being thrown into vibration by sounds made in the neighborhood."

There is, however, in that statement nothing whatever to indicate that in his patent No. 174,465, he had described or shown that special form of transmitting instrument, figure 7, as having any other functions, or being used for any other purpose than the forms of transmitting instruments thereinbefore described. The change made is what he had found by his clock spring experiment to be necessary in order to make a talking telephone. All the others had been for multiple-telegraphy, and there is no suggestion in the second patent that it had been the intention of the first to describe figure 7 as for any other purpose. In this patent, No. 186,787, Mr. Bell clearly and definitely describes the instruments therein shown as being for the purpose, among others, of multiple-telegraphy. He says:

"In order to transmit a telegraphic message by means of this instrument, it is only necessary for the operator at the telephone to make a musical sound in any way in the neighborhood of the plate A, and to let the duration of the sound signify the dot or dash of the Morse alphabet, and for the operator who receives the message to listen to his telephone. When two or more musical signals are being transmitted over the same circuit, all the telephones reproduce the signals for all the messages; but as the signals for each message differ in pitch from those for the other messages, it is easy for the operator to fix his attention upon one and ignore the other."

And later on he gives a description of its use for the purpose of transmitting articulate speech. He says:

"To convey an articulate message, it is only necessary for an operator to speak in the neighborhood of his telephone, and for another operator at a distant station upon the same circuit to listen to the telephone at that station. If two persons speak simultaneously in the neighborhood of the same or different telephones, the utterances of the two speakers are reproduced simultaneously by all the other telephones on the same circuit; hence, by this plan, a number of vocal messages may be transmitted simultaneously on the same circuit in either or both directions."

He had got rid of his hinged or pivoted armature, and now had a speaking telephone.

Surely nothing could be plainer than the language of this patent to indicate that the patentee had in mind and purpose the use of his instruments for purposes of multiple-telegraphy. Surely nothing can be more cogent as to the proper construction of patent No. 174,465, in limiting it to purposes of multiple-telegraphy, and as showing that the inventor had in mind only its use for purposes of multiple-telegraphy, than the fact that the second patent, when the inventor had definitely discovered or invented the use of an instrument for telephonic purposes, refers to the use of the instrument in the first patent only for purposes of multiple-telegraphy and refers to the instrument described in the second patent as available for multiple-telegraphy and also for the purpose of the transmission of articulate speech.

Turning now to the English specification, as amended by the disclaimer of February 13, 1878, we find equally cogent evidence that the first patent was a patent for multiple-telegraphy. The English patent, as amended by the disclaimer, will be found on page 1454 *et seq.* of the record. In the fourth plan therein shown a telephone substantially like that described in the United States Patent 186,787 is described. The specification as to the fourth plan begins by describing, substantially, figure 7 of the patent 174,465. It uses, however, this language (page 1466):

"When a musical note is made in the neighborhood of the "membrane N it is set in vibration; the armature *A* is forced to "partake of the motion and thus electrical undulations are created "upon the circuit. The armature A^1 is thus thrown into synchro- "nous vibration with the armature A embodying the musical "note of similar pitch to that which originated the vibration "of the armature A. If two or more musical notes be sim- "ultaneously sounded in the neighborhood of the cone C^2, the "resultant motion of the air is copied by the membrane N to which "the armature A is attached, and this armature A acting induct- "ively upon the current traversing the coils of the electro-magnet "E causes an increase and diminution in its intensity and the arma-

"ture A^1 is thrown into vibration by the varying direction of the "electro-magnet E^1, to which it is attached, and thus imparts to "the air at N^1 a *fac-simile* copy of the motion of the air that acted "upon the membrane N. Hence, two or more musical notes or "telegraphic messages can be sent simultaneously along a single "circuit from one station to another by means of one instrument at "each station."

Surely that description of the character and function of figure 7 is as clear and precise a description of its use for multiple-telegraphy only as could be desired. It is immediately followed by a description of the telephone described in Patent No. 186,787. As to that also it is specifically pointed out that it may be used for purposes of multiple-telegraphy. The specification says:

"By this plan an operator at station, figure 21, may send a telegraphic message on a certain pitch while another operator at another station, say figure 22, is transmitting another message on a different pitch, and both sounds will be audible at all the stations in circuit. The receiving operator will pay attention to signals of only one pitch; hence, by this plan, the simultaneous transmission of a number of telegraphic messages over a single circuit and in the same or both directions, with a single main battery for the whole circuit and a single telephonic instrument at each station is rendered possible. Whatever sound is made in the neighborhood of any telephone is copied in *fac-simile* by the telephones of all the other stations. Hence this fourth plan is also adapted for the *entirely new use* of transmitting intelligibly *the exact sounds of articulate speech*. To convey an articulate message, it is only necessary for the operator to speak in the neighborhood of a telephone and for the receiving operator at another instrument to listen."

In this patent the two uses of the instrument are pointed out. In patent 174,465 nothing is said of anything but multiple-telegraph.

If, then, we are correct in this interpretation of the patent, which is the same as that given by the Examiner of Interferences, but which the Examiner of Interferences felt himself barred from adopting by the decision of the Circuit Court for the District of Massachusetts, the patent of Mr. Bell 174,465 does not de-

scribe a speaking telephone and is not a patent for a speaking telephone, but is simply a patent for another mode of vibrating the armature in a multiple-telegraph apparatus.

It may be suggested that this apparatus will actually transmit speech. The evidence on that point is contradictory. Capable experts, like Dr. Morton and Mr. Benjamin, have found it inadequate for such transmission; complainant's experts say that they have made it work. It is then suggested that although Mr. Bell had not actually transmitted speech in pursuance of his theory, yet if in the patent he actually pointed out an instrument, or described an instrument which would produce the desired result, he had sufficiently reduced his invention to practice to comply with the law in that respect. Gray gives a far better description than Bell of a telephonic device; but inasmuch as he had not tried it or made it work in any satisfactory manner, he did not regard it as deserving the name of invention. In this respect the question would arise whether Mr. Bell had sufficiently described his method and apparatus to enable a person skilled in the art to make and use the instrument. How can we have better evidence on that point than the fact that Mr. Bell, with all the skill of which he was master, was unable to make an instrument which would work? Of what use is it to produce instruments which since that time are alleged to have been made by electrical experts simply from the drawing in the patent intended only as an electrical diagram and which it is said will transmit speech? How can the instrument maker divest himself of the knowledge which has since become the common property of the world in respect to the essential requisites for making an instrument capable of transmitting speech?

Were a million witnesses to come and testify that from the patent alone they had made an instrument which would transmit speech their testimony would be

valueless as against the admitted fact that Bell, with all his knowledge, added to that which was expressed in the patent was unable prior to the date of his patent to make an instrument which would transmit more than a faint sound, or give more than a kind of faint muttering. Mr. Bell and his assistant have attempted to reproduce instruments used by them prior to the date of the patent of March 7, 1876. Two peculiarities will be noticed with regard to all these instruments said by them to be reproduced. In the first place, they all had devi es for regulating the distance of the armature from the magnet. Figure 7 has none. In the second place, in every one of these instruments the armature was hung parallel with the end of the magnet and with the diaphragm. In figure 7 it will be noticed that the armature is hung at an angle with the diaphragm and consequently at an angle with the end of the magnet. In figure 7 the armature is shown large and heavy. In the reproduced instruments the armatures are shown exceedingly thin and light. Drawings of the reproduced instruments will be found on pages 1662 to 1665, and also on pages 1898 to 1907. If it be answered that these differences are experimental, and that the best of the lot and the one which should be effective could be readily learned by experiment we answer that such deficiency in a process or a device for a new art, one theretofore not known, is fatal. Who was to tell or how were they to learn that the difficulty in an instrument made precisely like that in Figure 7 was attributable to such points as these to which we have alluded, or to others? It was the business of the inventor of the new art to advise people who read his patent not only that figure 7 was another mode for vibrating the reed or armature for the purposes of multiple-telegraphy, but also that it was in and of itself an invention by which articulate speech could be transmitted; and it was also his duty then and there to inform them how to construct an apparatus which should fulfil the function of

transmitting speech, not by a mere electrical diagram, but by a statement so clear and definite that an ordinary artisan might execute it, and without experiment. That a clear and precise description, not only of the mode of operation, but of the concrete machine in all its details, which should be operative to transmit speech; or, in other words, which should practically carry out or execute this new art should be found in the patent is most emphatically shown by the complainant's own witness, Prof. Cross. On his cross-examination, page 81, he was asked as cross-interrogatory 44 the following question:

"At the time of the filing of the specification and patent No. 174,465, was the art of transmitting articulate speech by electricity known, unless it be described in the specification?

"A. It was not.

"Cross-Interrogatory 45. At that time was the art of transmitting musical tones, including vocal musical tones, by electricity known?

"A. The art of transmitting the characteristic pitch of musical sounds, including the pitch of a sound produced by the voice, was known. The transmission of all the characteristics of any sound—its intensity, its pitch and its quality—was not known.

"Cross-Interrogatory 46. Didn't you, in your last answer as to what was not known, describe an art which, if known, would have been the art of transmitting articulate speech?

"A. The *theoretical* knowledge of the manner in which the one could be done would, I think, necessarily involve the theoretical knowledge of the way in which the other could be done. *The practical realization* of an instrument which should transmit the three characteristics *of pitch, intensity and quality of a musical sound, would not necessarily involve the practical realization of the transmission of articulate speech.*

This precise defect referred to by Prof. Cross, we submit, is found in this patent. Assuming that Prof. Bell thought he had discovered, and even that he had discovered and invented a method and instrument which should transmit the three characteristics of pitch, intensity and quality of a musical sound, he had not discovered or invented, and did *not in his patent point out the* discovery or invention which should "necessarily involve the practical realization of the transmission of

articulate speech," or which did involve it. Further discovery and invention were necessary.

That the patent was insufficient for this purpose, we again repeat, is conclusively shown by Mr. Bell's own failure to effect the desired result; and no amount of evidence by men who have manufactured telephones at a subsequent date that they had made devices in accordance with the patent 174,465, and had with them transmitted speech would be sufficient to show that at the time the specification was filed any man could have read it and have done so.

Counsel for complainant are very fond of saying a Morse key and sounder delicately adjusted may be now made to transmit speech. Certainly, the House Phonetic Telegraph patents, which were introduced by the complainants themselves, would in the light of our modern knowledge undoubtedly, if properly adjusted, transmit speech. Can it be said, however, that the House patents are patents for telephony, or that the long use of the Morse key and sounder are anticipations of the modern telephone?

Second.

If, however, it can be claimed that the first patent is a patent for anything beyond the multiple-telegraph, we submit that it cannot be construed as a patent for anything but a magneto-electric telephone, and that the "*method*" of the fifth claim is the method of a magneto-electric telephone. That Mr. Bell invented the magneto-electric telephone may be conceded; that he invented it until subsequent to the issue of his patent 174,465, seems to us inconsistent with the evidence. The invention should properly date some time in the latter part of March or in April, 1876, when, by glueing a piece of clock spring to the membrane, he,

for the first time, obtained anything approximating to the transmission of speech. Prior to that time he had been working with a theory, but was unable in practice to verify his theories. Giving him, however, the benefit of the experiment in March or April, 1876, after the date of his patent, the same as if it had been described in his patent, we submit that the patent is still only for a magneto-electric telephone, and that the claims must be construed as limited to that device and that method.

As will be remembered, in the history given of the course of Bell's experiments and mental processes in arriving at his invention, the prominent and special feature in his mind was the use of *magneto-currents*. He says that their importance and theoretical availability became apparent to him at a very early date, and he says that he failed to avail of their beneficial use because he was impressed with the idea that they were too feeble to produce audible effects at a receiver. In speaking of the use of the magneto currents for purposes of transmitting speech he invariably described it as his "method." In his greatly-relied-on narration to Prof. Blake in October, 1874, he says that he described to Dr. Blake his "*method for the transmission of articulate speech*" (Answer 46, page 1598). The method described is the magneto method.

Ans. 46, p. 1598, and referring to October, 1874:

> "I described *my method* for the transmission of speech." * * * "I also described *this method* to Mr. Farmer." * * * "I also spoke of it to Mr. Sanders and to Mr. Hubbard."

He illustrated them by Figs. 7 and 8, pp. 1595 and 1596, which had free reeds before magnets and one of which is known as the harp instrument (Fig. 8).

Prof. Blake shows them by drawings on a sheet between pages 1874 and 1875. All the drawings show reeds—none show a membrane—reeds vibrate at a rate of their own. Mr. Bell, as we have seen from his

preliminary statement in the interference case (p. 2078), then thought that a membrane would do the same. And if a membrane was talked of, as Prof. Blake says it then was, it necessarily must have been as a mere alternative way of actuating the armature, and with the purpose of providing as in June, 1875, he did, a receiving reed tuned to vibrate in unison with the membrane transmitter.

The method then referred to must also be understood in memory of the fact that Mr. Bell had not then thought of the possibility of producing electrical undulations by vibrating the wire to which he first referred in his letter to Mr. Hubbard on May 4, 1875, following (p. 1604).

In his letter to Mr. Hubbard of May 4, 1875, after speaking of the feebleness of the induced currents by the magneto method, he refers to a *plan*, or theory of varying resistance, which, as we have seen, was substantially abandoned. The word *plan* is used as a synonym of *method*, and in his English patent it is used instead of method. These reflections are continued and shown in various ways until the accidental discovery of June 2d, that a magneto-current induced by the vibration of the armature in front of the pole of a magnet was strong enough to produce audible results. That was the great discovery; that was the discovery which he immediately proceeded to utilize; that was the discovery pursuant to which he immediately caused to be made a membrane transmitter and used it in connection with a reed receiver; and that, and that alone, is the discovery which he claims to have utilized in the invention, whatever it may be, set forth and described in figure 7 and the relating part of the specification, and that is the *method* in the 5th claim referred to.

Now, it must be remembered by the Court, that although the patent 174,465, does describe in a general way various devices by which undulatory currents may be created, it describes them solely and exclusively

with reference to the mere creation of such undulatory currents as might be availed of for multiple-telegraphic purposes, or such as would be appropriate for use in connection with figures 5 and 6. Nor does it speak of such methods for causing undulations as in any degree novel; on the contrary, in commencing the description of them it uses this language: "It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet," &c. And again, later: "There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify."

All the methods which he then proceeds to specify were well known at the time. He gives no description of an apparatus for any of the modes for causing undulations except one, and that one is the apparatus described in Figures 5 and 6. When, however, he comes to describe Figure 7, there is to be found in the patent no suggestion whatever that there is any other "method that may be employed." If Figure 7 and its descriptive specification are not intended merely as another mode for actuating the transmitting reed of a multiple telegraph instrument, and if they are to be considered as a separate and distinct invention, then we desire thoroughly to impress upon the Court the fact that there is not in the patent the faintest suggestion anywhere that there is or can be any other "*method*" whatever for effecting the purpose designed to be effected by Figure 7 than the particular *magneto-method* wherein the magneto current is created by the action of the voice on the diaphragm that is in the patent described. It is not to be supposed that, had Mr. Bell then believed, or had he then discovered or retained in his mind the mental conception that it was possible to produce the results, now claimed to be shown by Figure 7 and the specification, by means of any other method,

such as one in the nature of a microphone, he would not have said in that part of his patent, as he had said in reference to the multiple telegraph in the prior part of his patent, that there might be various modes or methods for effecting the result, one of which was described in Figure 7 and the relating specification. If, however, there had been what we see, in fact, that there was in his mind, the conception that the magneto-method was *the* method, which he had invented for carrying out the purpose of transmitting speech, we can see that the patent properly and fairly expresses that idea.

Our scientific knowledge has in the last fifty years been *greatly* expanded. One result of this vastly increased knowledge is a wonderfully broadened generalization. Principles which were thought to be of narrow and defined application are discovered to exist practically everywhere, and in every form of life and matter to show their proper application. The effect of this has found its way into the patent law. Men invent devices or processes of a definite and special kind and for definite and special purposes; subsequent and different inventions are made, when at once the prior inventors find that by the greater diffusion of knowledge some broad general principle exists equally in both sets of inventions. In other words, after an invention has been made, another set of inventors (ordinarily called patent lawyers) are employed to invent some theory or principle which can be shown as common to that and the subsequent invention and to make the latter infringe upon the former. Carried out to its logical conclusion, this doctrine would stop all invention the moment a patent for any new thing had once been granted. The doctrine of the correlation of forces is now so broad, so generally received and so universal in application that there is no difficulty in showing that every invention is founded upon a theoretically identical law. The present case is a complete

illustration. Mr. Bell invented a process, so to call it, for the utilizing of magneto currents. His first conception, free from form, is that magneto currents would produce certain results. His practical invention is of a machine to utilize them. Now, his counsel claim that when he described in his patent only a method by which magneto currents could be generated by the action of the voice, he also informed the world that the same result could be attained by the introduction of a microphone in a continuous voltaic current, when there is in the patent not the faintest suggestion that anything of the kind could be done, and because the same "mathematical conception" may be invoked to explain the phenomena in each case.

Again turning to Mr. Bell's preliminary statement (p. 2073), we find him saying that he was led to the "conception of '*a method*' of transmitting simultaneously along a single circuit a number of distinct telegraphic messages, by means of musical sounds."

* * * The *plan* which he conceived was to use *transmitting instruments* of different pitch, &c., and he then describes a magneto "method" or "plan."

We do not desire here again to repeat extracts and references to the testimony of Mr. Bell and his witnesses, showing the sense in which he used the word "method," and what he meant by it. We must, however, refer to a few, and trust that the Court, in reading the testimony of Mr. Bell, will bear in mind its relevancy to the construction of the term "method," as used in his patent.

In his letter of August 14, 1875, to Mr. Hubbard (pp. 1617–18), he dwells emphatically on the magneto-electric current as *in* contrast to making and breaking, and as the thing to be protected by caveat or patent, no matter how produced.

On page 1660, Mr. Bell was describing his mental state in the summer of 1874, and says that he was firmly convinced that speech would be produced by the

apparatus he had "devised," but he thought the vibrations produced would be too minute to be perceived as sound by the unassisted ear. At that time he proposed to take advantage of magneto-electric currents produced by the vibration of an armature actuated by the voice of a speaker, so that the electrical current employed would be produced by the action of the voice itself, and not independently of it. He is so far clearly referring to the magneto method described in his patent.

He refers to some difficulties, and then adds:

> "During the winter of 1874 and spring of 1875, this feeling led me to seek some "*method*" by which the voice, instead of producing the electrical current used, should merely modify a current produced by other means."

He then describes his wire experiment, and adds: "I was still carrying on experiments and researches regarding *this method*," when the accidental discovery of June 2d, 1875, turned him back to his first magneto method.

On page 2074 he says that in developing *his plan* of multiple telegraphy certain difficulties made their appearance. That plan, as we have seen on the preceding page, was the use of transmitting instruments of different pitch to actuate receivers of corresponding pitch. He then says that he devoted himself to devising means to overcome these difficulties, and in stating what he did, goes on to say that he "then saw that two similar instruments might be placed in a circuit and that the vibration of the armature of one would produce corresponding vibrations in the armature of the other, &c. * * * It will be understood, of course, that both armatures were to be tuned to the same pitch. I then conceived the *plan* of attaching a number of springs of different musical pitch to each pole of a permanent horse-shoe magnet, so that the two sets of springs should lie in parallel planes."

It does not need argument here to show that by the words or phrase "the plan" Mr. Bell there meant, not the mere effect of the transmitting instruments upon the electric current in the line wire, but he meant the whole thing, that is, the plan or method by which the result should be accomplished, which included the transmitting instrument, the connecting wire and the receiving instrument. Mr. Bell then goes on to narrate historically the mental processes by which he arrived at the idea, as stated on page 2076, that a single armature might be used instead of the many armatures of his transmitting instrument, which might be put in motion in such a way as to induce directly a current which should correspond to the resultant current due to the vibration of the armatures, which should respond to the fundamental and overtones of the sound, and then says: "The question then arose in my mind whether an armature might not be set in motion by a membrane similar in shape and structure to that in the human ear, so as to produce a current which should correspond to the vibrations of the air." That he did not at this time devise any *method of combining a membrane with an armature.*

The Court will notice that Mr. Bell here clearly and plainly uses the word "method" with respect to the mode or manner of effecting electrical action and with respect to the combination of a membrane with an armature as the means or method whereby electrical action should be created by the action of the voice; or, in more direct terms, should be created by the voice itself. He says, on page 2077, that he never constructed these instruments which he had devised, referring, as he says, to the instruments made up of a number of armatures—because he thought that the magneto current would be too weak to produce any useful effect. But the Court will note that while he had, in his own language, "devised" the instruments with many armatures, but not constructed them, he says himself at the foot of page

2076, that he had not yet even *devised any method* of combining a membrane with an armature. Subsequently, and in his patent, and as a consequence of the experiment of June 2, 1875, he did devise this method, and when we find in the fifth claim of his patent the claim for a method, if we look back at the history of his mental processes described by himself in his own language in a paper prepared with the utmost care as the preliminary statement in his interference case, we find what use he attaches to the word method, and what he means when he speaks of his *method* in the fifth claim; that is, he means the method which he had not devised when the theoretical conception first occurred to him, but which he subsequently did devise; that is, the method of combining a membrane with an armature in order to produce a current which should correspond to the vibration of the air. On page 2077 he says that he did, however, shortly after his return from Canada, have several interviews with Dr. Blake for the purpose of showing him the experiments he had made and of obtaining further information with regard to the structure and mechanism of the human ear, to aid him in his efforts to devise *a method of producing vocal sounds electrically*, and that they carried on a series of experiments to obtain tracings of the vibrations of the bones of the human ear. The Court will note here the sense in which the word "method" was used by Prof. Bell. It certainly was not what his counsel would now have us believe is the sense of the word in the fifth claim; that is, the mere existence of electrical undulalations corresponding with the aerial undulations, because that idea was already, according to Prof. Bell himself, clear and distinct in his mind, and the only difficulty in his mind with the practical realization of that idea was that the electrical currents would be too weak to produce practical results. The aid, therefore, that he was invoking from Dr. Blake was in finding or devising a method of making these sounds of practical

use, or, to use his own language, a method of producing vocal sounds electrically; and the experiments made by them and the devices explained were all methods for the practical production of these sounds, and no discussion or investigation seems to have been had by or between either of them with reference to the mere question of the theoretical sufficiency of magneto-induced currents to produce the desired results; the question was some practical means or method for carrying the conception into effect.

At the bottom of page 2078, Mr. Bell makes a somewhat important statement. He again says that he had an apprehension or belief that the magneto-currents would be too weak to produce audible results, and that his thoughts were directed to utilizing the current derived from a battery, the strength of which should be made to vary by varying the resistance of the circuit through which it was passed. It must be remembered that this statement was made in November, 1878, after the magneto-telephone had been in existence for a considerable period of time, and after Mr. Hughes and Mr. Edison had invented the microphone, and he uses terms which had then become popular. He adds: "I sought to discover *some method* of varying this resistance proportionally to the varying vibration of the air."

The Court will notice the clear meaning of the term "some method" in this connection; the other method or plan to which he had been theretofor referring in this preliminary statement, had been the method or plan of producing the electrical currents by the voice. In contrast to that method or plan of which he had before been speaking, he now speaks of some method of varying the resistance proportionally to the varying vibration of the air. He then goes on to quote from his letter of May 4, 1875, wherein he had spoken of the vibration of the wire through which an electrical current was passing, as varying the resistance to the cur-

rent by the varying tension of the wire during its vibration, and that if such should turn out to be the fact, one consequence would be that the *timbre* of a sound could be transmitted, and then adds, as contrasting two plans or methods: "*The plan* for transmitting *timbre* that I explained to you before, viz., causing permanent magnets to vibrate in front of electro-magnets is chiefly defective on account of the feebleness of the induced currents. If *the other plan* is successful the strength of the current can be increased *ad libitum* without destroying the relative intensity of the vibration."

We again call the attention of the Court to the emphatic manner in which Mr. Bell here contrasts the two plans or methods for transmitting *timbre*—one the magneto-electric and the other the varying-resistance. He describes them as two plans or two methods distinct and different, and refers to the advantages and disadvantages of either.

Now, in addition to these affirmative proofs of the sense in which Mr. Bell used the word "method," we have in this same preliminary statement two facts negative in their nature and which are inconsistent with the idea not only that he intended any such broad signification as is now given to the term by his counsel, but even with the idea that he intended or supposed this instrument was for any other purpose than a multiple telegraph. Both of these statements are found on page 2078; the first is that he had the impression on his mind that a stretched membrane would have a rate of vibration peculiar to itself. Assuming that to be so, and remembering that in his patent he describes figure 7 as another mode of imparting vibration to the armature, it would seem plain beyond controversy that in describing figure 7 and its mode of operation and method Mr. Bell was referring to the method or manner by which motion could be imparted to the armature by attaching it to a membrane and causing a sound in the

immediate neighborhood of the membrane. The other fact is the statement that at the time Mr. Bell had no idea of the extreme minuteness of amplitude which could produce a sound. That minuteness we now know is expressed in figures of whose minuteness the mind can form no practical conception, being from one 2-1000ths to one 10-1000ths of an inch. Nor could Mr. Bell's mind have been in any degree enlightened upon this point by the experiment of June 2, 1875; for in that case the transmitting reed was plucked, thus giving it a vastly larger vibration than any which could be imparted to it by the voice, and the receiving reed vibrated visibly, thus vibrating with an amplitude vastly larger than could be imparted to it by the voice. There was nothing, therefore, in that experiment to disabuse Mr. Bell's mind of the idea that vibrations caused by the voice would be too minute to produce audible sounds.

If now we turn to the patent 174,465, we are reinforced in our idea as to the meaning ascribed by Mr. Bell to the word "method" and as to the method to which he referred in his fifth claim. He begins his specification by the statement that in prior letters patent he had described "a method of and apparatus for transmitting two more telegraphic signals," and he there describes the method as the employment of transmitting instruments each of which occasions a succession of electrical impulses differing in rate from the others, and of receiving instruments each tuned to a certain pitch, and of vibratory circuit-breakers operating a morse sounder or register placed in the local circuit. He states that upon that *plan* he has found that the limit to the number of signals is very speedily reached, and gives the reason. He then says that his present invention consists in the employment of vibratory or undulatory currents of electricity in contradistinction to a merely intermittent or pulsatory cur-

rent, and of *a method of* and apparatus for producing electrical undulations upon the line wire.

We ask the Court to note here the use of the phrase "of a method of;" it is his method of *producing* undulations which Mr. Bell states is his invention. This is in precise accord with the use given by him to the term in his oral testimony and in his printed statements, both before and after the patent. After having given sundry illustrations of the difference between an undulatory and intermittent current of electricity, the employment of the former of which Mr. Bell had stated to be part of his invention, he says that, "There are many ways of producing undulatory currents of electricity dependent for effect upon the vibrations or motions of bodies capable of inductive action; a few of the *methods* that may be employed he will there specify." He then goes on to describe a variety of ways in which undulatory currents of electricity may be effected; he then adds, "In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect." And he proceeds to describe figure 5 of the patent. Now, he had already said that his invention consisted in the employment of an undulatory current and of *a* method of producing electridal undulations. After speaking in a general way then of many methods by which electrical undulations might be produced, he illustrates *the* method—that is, the method invented by him—by description of figure 5.

In no part of his patent does Mr. Bell give us any other statement of what it is that his invention consists than the one already quoted; that is, that it consists of the two elements—the employment of an undulatory current of electricity, and of a method of producing electrical undulations, together with an apparatus for that purpose. This view of the meaning of Mr. Bell is strengthened when we look at the claims. The first claim is directed to secur-

ing the use of an undulatory current for setting in motion a receiver; the second is for the combination of a permanent magnet with a closed circuit; the third claim first uses the word "method" and it is for "*the method of producing undulations* in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of a conducting wire itself in the neighborhood of such bodies, as set forth." The fourth is for *the method of producing undulations* in a continuous voltaic circuit by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing and diminishing the power of the battery. These 3d and 4th claims beyond question, refer to *methods* in the abstract for producing undulations, there being no apparatus described for carrying the method into effect, and the method being described only in a general way. They refer to general statements in the specification preceding any description of apparatus, and in no way suggest the creation of undulations by sound waves. The fifth claim is for "the method of and apparatus for transmitting vocal or other sounds telegraphically, *as herein described*, by causing electrical undulations similar in form of the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth." Had the method herein referred to been disconnected from any apparatus for, as in the preceding third and fourth claims, Mr. Bell undoubtedly would have described it, as he did describe the methods of the third and fourth claims, to wit, the method of producing undulations in a continuous voltaic circuit similar in form to the vibrations of the air which should cause the vibrations of the transmitting instrument. In such case, his specification would doubtless have been different. It would have been something to the effect that if the transmitting instrument were actuated by the voice, the receiving instrument would produce vibrations similar to those which caused the vibration of

the transmitting instrument, and the claim would then have been of "the method of producing undulations in a continuous voltaic circuit similar in form to the vibrations of the air effecting the vibration of the transmitting instrument." Such a description and such a claim would undoubtedly have referred, as the term "method of," used in the third and fourth claims, undoubtedly do refer to the particular means or method of producing the undulations. Claim 5th differs simply in that it describes or refers to an apparatus as well as a method, and therefore involved some change in the verbiage from that used in the preceding claims 3 and 4. It will be noted, however, that the claim is of the method and apparatus as therein described. Now, when we turn to the description, we find absolutely nothing but a description of the apparatus and a statement of the result. The only *method* described is the method of attaching one extremity of the armature to the centre of a stretched membrane, the use of a cone to converge sound vibrations and the utterance of a sound into the cone. If there be anything else in the nature of method which is therein described, it can be nothing but that which has theretofore been described, of the effect of the vibration of the armature in front of the pole of the magnet. This claim is not addressed to the undulatory current or to the closed circuit; but even if it were, it could only refer to them as part of the method of producing electrical undulations by the vibration of an armature attached to a membrane. It cannot refer to the methods specifically pointed out in the third or fourth claims by the vibrations specified in the third claim or by the varying resistance specified in the fourth claim. We are absolutely shut up to the method described in the one paragraph on page 53, which is that, and only that, of vibrating the armature by means of a stretched membrane to which it is fastened, which membrane is to be put in vibration by sound, or by sound waves.

We submit that there is no principle in patent law more clear than that the claim must be construed and limited according to the description and the specification. The claim may be, and should be, limited by the specification, but on the other hand the specification, or, in other words, the invention, cannot be enlarged by the claim. We have elsewhere referred the Court to the doctrine and the cases on this point.

Looking now at the specification, wherein are we told that the creation of electrical undulations similar in form to the air vibrations caused by a sound will reproduce such sound at a receiver? How, or in what way does that specification inform the world that all that need be done to reproduce speech or to reproduce sounds is to cause electrical undulations similar in form to the air vibrations? Surely, the patent itself says no such thing; surely no such method is pointed out in the specification. But a method is pointed out in the specification of quite similar character to the methods pointed out in other parts of the specification and referred to in the other claims, whereby electrical undulations of a certain character may be produced; that method, as we have before said, is the method of causing the vibration of the armature by attaching it to a stretched membrane and then causing a sound in the neighborhood of the membrane. That is the method which any one reading it would naturally suppose was referred to and intended to be described, and that is the method which the claim refers to when it follows up the general phraseology of causing electrical undulations similar in form, &c., by the words "substantially as set forth," and which words, even if they were not added, would by the patent law be implied. It is also well to remember that the words "by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds" add nothing whatever to the description of *method*. The practical question of invention was—How to do it?—

not any theoretical explanation, or even any scientific explanation of the phenomena in and by which it was done. The method of the patent law is a practical method; it is the actual thing to be done by the operator in order to effect the result. Method in the sense of the patent law can be only that operation which shall result in the thing desired, and in the practical sense of the patent law we have not advanced a step towards that result by any theoretical conception of how it may be done until some concrete action is invented and described.

Now the concrete thing involved in this telephone was the keeping of the electric current under the constant control of the voice or of the sound. The only method applicable to the case, in the sense of the patent law, is a method which will effect, or may effect, or does effect that result. Mr. Bell invented a method for effecting that result, which was the use of a closed circuit and the creation of the electrical current by the movement of a diaphragm actuated by the voice. That is his *method*. This practical patent law method is in no way influenced or affected by any notion, correct or otherwise, as to the character of the current in the wire, whether it shall be similar in form to that of the air waves or not. In illustration we refer the Court to Cross-question and Answer 73, p. 643–644, of Prof. Morton:

"Q. Did it, in your opinion, require any invention or discovery to construct a closed-circuit telephone and to develop the mode of operation therein contained, in view of the fact that Reis' apparatus and Reis' descriptipn were known to the public?

"A. To produce a practically efficient closed-circuit telephone did, in my opinion, involve a great many inventions and discoveries in addition to all that was given to us by Reis; but it is also my opinion that among those inventions and discoveries this so-called invention or discovery, that the current in the wire must express undulations corresponding to those of the moving particles of air, was *neither necessary nor important*. Reis showed us how to transmit speech imperfectly; various improvements, such as the use of

carbon in the transmitter and the use of a metallic diaphragm in the receiver, were essential to make this transmission of speech practically available. But, in my opinion, this practical development was in no way influenced by any notion, correct or otherwise, as to the character of the current in the wire."

If now we turn to the testimony in the case, we find that all the experts examined by the defendant agree in this: the method referred to in the fifth claim is, as we have said, the practicable, patentable method of effecting the result as shown in the patent; that is, the magneto method or the method of producing an electrical current by the action of a sound upon the diaghragm. To extract this testimony would be to rewrite the record. Prof. Channing, Prof. Young, Prof. Brackett, Prof. Morton all so testify, and a large part of their cross-examination is devoted to that subject. We submit their testimony to the Court in the hope that it may be thoroughly read and given such weight as it may deserve. We will make one single quotation from Prof. Young, on page 413, cross-question 70, in these words:

"Is not the method of the magneto transmitter in Bell's specification to vary the strength of the current in accordance with the variation of the air waves in transmitting a sound? (A.) This is the *effect* of the transmitter as I understand it; the *method* by which the effect is produced is the production of electric pulses in the wire by a magneto-electric induction due to the action of an iron or steel armature vibrating in front of the poles of a magnet."

Third.

A further reason for restricting the construction of this patent to a claim for the magneto current or magneto telephone is found in the fact that if the claim is given the broad construction asked for it by the complainant, it would be void, as a patent for a theory. It is said that a patent cannot be given for a principle.

This patent, upon the construction claimed for it by complainants, is far beyond a patent for a principle; it is even, we submit, far beyond a patent for a theory, and can properly be described no otherwise than as a patent for an hypothesis. The patent on the construction claimed gives to the patentee a monopoly for transmitting vocal or other sounds by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds. Now, the method described is the *causing* electrical undulations; it is not only *causing* electrical undulations, but causing electrical undulations similar in form, &c. This also, according to the complainants, is disconnected from any means or apparatus for effecting such undulations. If any one transmits sounds by effecting unduations similar in form, he, upon their theory, infringes that patent. That description, it is said, describes an art or a process which may be the subject of protection under the patent law.

Now, Sir William Thomson, who is the great exponent of all that is righteous and holy, according to the complainants, describes this so-called art or process as a "mathematical conception." His words are found on page 1799, and refer not at all to the device of figure 7, but to the later and more advanced inventions which were used by Mr. Bell at the Centennial. They are as follows:

> "Who can but admire the hardihood of invention which devised such very slight means to realize the *mathematical conception* that if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sounds."

A drawing of the instruments to which Sir William Thomson had reference is shown upon the same page. The Court will note now that it is not what Sir William Thomson calls and describes as the *invention*

of Mr. Bell, to wit, the very slight means shown in the drawings underneath, but it is the "*mathematical conception*," referred to by Sir William Thomson, that if electricity is to convey all the delicacies of quality, &c., the strength of its current must vary, &c., the monopoly of which is now claimed by Mr. Bell and his successors in the patent.

On the preceding page, 1797, Sir William Thomson again expresses himself substantially to the same effect. He says:

"Mr. Bell perceived that he must produce a variation of strength "of current in the telegraph wire as nearly as may be in exact pro- "portion to the velocity of a particle of air moved by the sound, "and he invented *a method of doing so*—a piece of iron attached to "a membrane, and thus moved to and fro in the neighborhood of an "electro-magnet—which has proved perfectly successful."

And he then goes on to describe in more detail the *method* so invented.

We now desire to call the attention of the Court to the condition of our knowledge, even after instruction by Mr. Bell, as to electrical phenomena.

Prof. Morton (page 663, 141st answer) says:

"I think it is universally admitted by all writers on this subject that we really have no knowledge whatever as to the final cause of an electrical current or other electrical phenomena. As to the views entertained by the highest recognized authorities on this subject, I should refer in the first place to a passage in a work entitled 'A Treatise on Electricity and Magnetism,' by Maxwell, in which he says: 'It appears, therefore, that a system containing an electric 'current is a seat of energy of some kind, and since we can form no 'conception of an electric current except as a kinetic phenomenon, 'its energy must be kinetic energy; that is to say, the energy which 'a moving body has in virtue of its motion. We have already 'shown that the electricity in the wire cannot be considered as the 'moving body in which we are to find this energy, for the energy of 'a moving body does not depend upon anything extrinsic to itself; 'whereas the presence of other bodies near the current alters its 'energy. We are therefore led to inquire whether there may not be some motion going on in the space outside the wire which 'is not occupied by the electric current, but in which the

'electro-magnetic effects of the current are manifested. I 'shall not at present enter upon the reasons for looking in one 'place rather than another for such motions, or for regarding these 'motions as of one kind rather than another. What I propose now 'to do is to examine the consequences of the assumption that the 'phenomena of the electric current are those of a moving system, 'the motion being communicated from one part of the system to 'another by forces the nature and laws of which we do not yet even 'attempt to define, because we can eliminate these forces from the 'equations of motion by the method given by Lagrange for any 'connected system.'

I would also refer to a work entitled 'Electricity and Magnetism' by Flemming Jenkins, in which, on page 1, I find as follows: 'There has been much wrangling as to the hypothesis of one or of 'two fluids. It is quite unnecessary to assume that the phenomena 'are due to one fluid, two fluids or any fluid whatever; but in this 'treatise the names employed will be chiefly those which have been 'suggested to men of science, by thinking of electrical phenomena 'as due to the presence or absence of a single fluid.'

"I would also refer to the work entitled 'An Introduction to the Theory of Electricity' by Linnaeus Cumming. On page 135 I find as follows: 'We have explained above in connection with Far-'aday's theory of induction the state of a medium acted on by elec-'trical forces. We then established, first, that in each molecule 'there was a separation of electricity along the line of force through 'the molecule, the quantity separated being measured by $\frac{r}{-4\pi F}$ unit 'of area where F is the resultant force at the point.

" 'Second, that this electrical separation, produces or is pro-'duced by a strain in the medium along the lines of force, from 'which strain or state the medium tends to return to a neutral state 'by a discharge from molecule to molecule through the medium.

" 'Third, that this discharge constitutes conduction, resulting 'in a transfer of the positive electricity separated to the place 'of lower, and of the negative electricity separated to the place 'of higher potential, the lines of flow being the lines of force 'and the quantity of electricity neutralized along a tube of force 'being .' "

In the testimony of Prof. Cross, answer to cross-interrogatory 43, in the Clay case, page 153, we find this statement:

"Conventionally we may speak of one of these bodies as electrified positively, and of the other as electrified negatively, these terms being only *mere conventions and not necessarily* implying the

truth of any particular theory. If we connect one of these bodies with the other by a wire we find that this wire acquires temporarily certain properties which it does not possess under ordinary circumstances. It will attract a piece of iron, or if it is coiled around an iron bar will render the bar magnetic. It will also deflect a compass needle from the north and south line if the wire is held parallel to the needle. The same effects will occur if either of the charged bodies is connected by means of a wire to the earth, or to an electrified body. We find that the charge of the electrified body under those circumstances rapidly diminishes to zero. It is evident from this, together with other facts, that some change is propagated along the wire, and in order to avoid circumlocution we *imagine* something which we call 'electricity' to pass from the charged body through the wire, and speak of these actions which I have mentioned, as due to what we call the 'electrical current.' We assume conventionally that the current flows from the positively to the negatively electrified body. It is very probable that there is something to which we give the name 'electricity,' which actually passes through the conducting wire along its molecules. From the observed effects of currents flowing in a wire upon magnets, and of magnets upon currents, we are led to infer the existence of vertical motions in the ether which surrounds all bodies. The phenomena of attraction and repulsion of charged bodies and of the reciprocating action between magnets and currents of electricity has been explained by Maxwell, as the result of tensions and compressions, and existing in small rotated motions of the ether. Maxwell has shown that the various known electrical phenomena can be accounted for by supposing the existence of a pull along certain definite lines known as lines of magnetic force, and a thrust in the direction at right angles to this, and he accounts for the existence of this pull and thrust by forces called into play from the vertical or rotary motion of small particles or cells of the insulating medium through which electrical disturbances are propagated; when a current passes through a wire, that is, vortices are produced in the space about the wire. I think that scientific men generally are inclined to accept, provisionally at least, the views which I have stated as explaining electrical phenomena. I prefer, however, in discussing electrical phenomena to avoid the assumption of any particular theory as to the nature of electricity. When I speak of a current of electricity as flowing through a wire, I mean it to be understood that the wire, in consequence of the electrical state in which it has been placed, exhibits various electrical and magnetic phenomena which, under ordinary conditions, it does not manifest. The condition assumed by the wire is capable of propagation from one point of the wire to another. We can also produce periodical changes in the condition of the wire, and hence in the magnitude of its electrical or magnetic effect. Variations, whether slow or rapid,

periodical or otherwise, in the magnitude of the electrical and magnetic phenomena manifested by the wire, we ascribe to similar variations in the electric current. We do not necessarily assume the truth of any particular theory in using these terms, but they are employed because of their well-known analogy which I have mentioned and their universal use as understood by those conversant with electrical science. It is probable, however, that there is actually a flow of something to which we give the name 'electricity' through the wire."

Again:

"Not knowing certainly whether there is an actual propagation of something through the wire, I can answer the question only by assuming the truth of some hypothesis. It is quite probable that in any conductor particles of something quite distinct from ordinary solids, liquids or gases, pass along the wire; to this we give the name of 'electricity.' We *are entirely ignorant of its nature*, but at the same time are capable of measuring, &c. * * * Nevertheless, we do not know what the *mode of motion in the* electrical current is, nor the nature of the material which moves. There is apparently a translation of something from place to place, but we know nothing whatever about the velocity with which the electrical current travels—which may be very great or very small—we have no means of knowing which."

Dr. Carl Seiler, examined in the Clay case, says:

"The transmission of electrical action along or within a conductor is to my knowledge neither explained nor understood by physiologists and electricians. Various theories have from time to time been propounded to explain this transmission of an electrical action through a conductor, but none of them has been, to my knowledge, unanimously accepted as explaining the transmission. A current of electricity, so called, is not known to exist as a substance and is only evidenced by the action it produces upon certain instruments which are capable of being influenced by electricity. I therefore understood (understand) 'current of electricity' to mean the transmission of electrical action, however directed, from the end of a conductor to a distant point of this conductor. The term 'current' has been applied to this electrical action, and it is evidenced in the same manner as the sinusoidal curve has been employed to represent a sound wave; that is, as a convenient illustration easily grasped by the mind and on which different phenomena may be exemplified."

Dr. Seiler is asked on cross-examination, question 41 :

" In every case, is it not true that when the armature is set in vibration, electrical undulations are created on the line wire? (A.) I am not prepared to answer this question either in the affirmative or in the negative, since I do not know what electrical undulations are. Electricity, as I understand, is not a substance, but what it is I do not know. I cannot *conceive undulation* to take place in or be produced *by anything but a substance;* I can therefore also state that I cannot conceive of electrical undulation, and would like to be understood that whenever ' a current of electricity ' or ' electrical current ' is employed by me in this testimony, it is a symbolic representation, not electricity in itself. I have heard and made use of the expression ' undulatory current,' distributing and changing the intensity of the electrical current, so called; but I have looked upon the expression merely as a makeshift to express something we know nothing about—a method by which electrical action is transmitted through a conductor."

We believe that there is no expert testimony in any of the cases in any degree in conflict with that above quoted. The value of such expressions as a convenient mode for describing certain phenomena we do not dispute; but we do dispute that this abstraction, this " mathematical conception," this theory or hypothesis, can be the subject of a patent and that a claim for causing the existence of this " mathematical conception " in a wire is not a claim which can be sustained by the Courts. In this respect the case is totally different from the case of Tighlman against Proctor in 102 U. S. Reports. Neither the claim nor the process in that case was for any abstraction or mathematical conception. The process was that of subjecting certain fatty substances to the action of water at a high temperature under pressure sufficient to prevent the formation of steam. The claim was the manufacture of fat acids and glycerine from fatty bodies by the action of water at a high temperature and pressure.
The decision was that such manufacture was a process and that any person who effected the result of manu-

facturing fat acids and glycerine from fatty bodies by the action of water at a high temperature and pressure infringed, notwithstanding he might have used a different apparatus in carrying out the process. That process effected certain chemical results; there was a form of matter existing prior to the application of the process; that form of matter, on being subjected to the process, experienced certain changes, and the product was the same matter which had existed prior to the application of the process, with such changes as had been effected in it by the application of the process.

In the present case there is matter neither at the beginning nor the end. The so-called process or method claimed by the complainants to be described and intended is a process existing wholly in *mathematical conception*, and is not applied to anything, nor is there anything which is the result of its application. It is, on the contrary, quite analogous to the claim which was held void in the case of O'Reilly against Morse, 15 Howard, 62. In that case, the eighth claim was for the "use as a motive power of an electric or galvanic "current, which I call electro-magnetism, however de-"veloped, for making or printing intelligible charac-"ters, letters or signs, at any distance, being a new ap-"plication of that power of which I claim to be the "first inventor or discoverer."

On page 726 in the Tilghman and Proctor case, the Court say:

"The eighth claim of the Morse patent was held to be invalid because it was regarded by the Court as being not for a process, but for a mere principle. It amounted to this, namely: a claim of the exclusive right to the use of electro-magnetism as a motive power for making intelligible marks at a distance; that is a claim to the exclusive use of one of the powers of nature for a particular purpose. It was not a claim of any particular machinery, nor a claim of any particular process for utilizing the power, but a claim of a power itself, a claim put forward on the ground that the patentee was the first to discover that it could be thus employed."

We submit that the fifth claim of this patent is substantially of the same character. We might use the language just quoted from the case of Tilghman against Proctor, page 726, substituting for the term "electro-magnetism" the term "electrical undulations," and it would be a perfect description of the fifth claim of Bell's first patent. It would then read:

"It amounted to this, namely: a claim of the exclusive right to the use of electrical undulations as a motive power for making intelligible signs at a distance. That is, a claim to the exclusive use of one of the powers of nature for a particular purpose. It was not a claim to any particular machinery, nor a claim of any particular process for utilizing the power, but a claim of the power itself, a claim put forward on the ground that the patentee was the first to discover that it could be thus employed."

The quotation made from the Morse case, on page 727 in the case of Tilghman vs. Proctor, is equally applicable and can be as readily transformed to suit this case, by the use of the terms "electric undulations," or "undulations," instead of "electric or galvanic current." The quotation would then read:

"He claims the exclusive right to every improvement where the motive power is electrical undulations, and the result is the making of intelligible sounds at a distance. If this claim can be maintained, it matters not by what process or machinery the result is accomplished. For aught that we now know some future inventor in the onward march of science may discover a mode of speaking at a distance by means of electrical undulations, without using any part of the process or combination set forth in the complainant's specification. * * * In fine, he claims the exclusive right to use a manner and process which *he has not described*, and indeed *had not invented* and therefore could not describe, when he had obtained this patent."

The Court must remember that undulatory currents and electrical undulations were known long before the date of this patent.

In the year 1833, Messrs. Gauss & Weber, of Gottingen, Germany, invented a telegraphic apparatus in which undulatory currents were employed. In 1840

Sir C. Wheatstone invented an instrument in which undulatory currents were used to operate a dial, which is shown in Exhibit No. 49, page 948, *et seq.* Another method and apparatus in which undulatory currents are employed similar to those described by Mr. Bell in patent No. 174,465, is set forth in the Varley patent 1044, page 917, *et seq.* "By my invention," says Mr. Varley, "I superpose upon the current used for working the ordinary telegraphs rapid undulations or waves. * * * And by a new apparatus hereinafter described, these undulations are made to produce distinct and independent audible or other signals so long as these undulations are produced, whether ordinary signal currents be flowing or not."

Further on, the inventor declares that sound signals are not new, they having been commonly used in the step-by-step instrument of Wheatstone to indicate the dot and dash of the Morse alphabet. The harmonic telegraph of Mr. Gray also uses an undulatory current.

Further than this, it will be seen that upon the construction claimed by complainants this claim is substantially a claim for effecting the result, no matter by what means or in what manner. A claim for transmitting sounds telegraphically by causing undulations, &c., is substantially neither more nor less than a claim for transmitting sounds telegraphically by means of electricity. That in and by itself is a mere statement of the problem. Bell so regards it in his letter of August 14, 1875. He says: "Where we can create a pulsatory action of the current, which is the exact equivalent of the aerial impulses we shall certainly obtain exactly similar results" (p. 1618). As we have seen, the term, "electrical undulations" means nothing in and by itself. The claim, then, must mean a claim for transmitting sounds telegraphically by so affecting the line wire that the receiver will produce vibrations similar to those of the transmitter. By using a term without meaning, assum-

ing to describe wholly unknown phenomena, nothing is gained and no advance is made. The problem before Bourseul and Reis was just exactly the problem stated by Bell—to wit, so as to affect the line wire by the action of the transmitter that it in turn would so affect the receiver as to cause air vibrations similar to those at the transmitter. The patent gives no hint or suggestion that this can be done in any other way than in the way pointed out by the patent. If we turn to the specification of the patent, it contains absolutely nothing to indicate to any person that anything has been invented or discovered by the patentee other than the function and result of the action of the machine as a whole described by him. He begins by describing it as another mode for effecting a prestated result, and his description is that of a machine, and only of a machine. His claim must be construed in connection with his specification, and, being so construed, it is either a claim for the result or object endeavored to be attained by his machine, in which case it would be void, or it must be limited to the particular machine or process described in the specification.

There is another aspect of this patent, pursuant to which we submit it must be held void as a patent for the new art or process of transmitting speech. That art or process is not described in the patent. By the patent laws, "any person who has invented or discovered any new and useful art, &c., may obtain a patent therefor." The patent when granted must contain sufficiently clear and definite instructions how to make or operate the machine, or how to practice the art, so that one skilled in the art may be able to make and construct without further aid than such as is derived from the patent the particular thing. In Wakeman vs. Corcoran, Law Rep., 13 Chanc. Div., page 65, the familiar rule of law is stated that "the specification of a patent is bad if a skilled mechanic would not, *without performing a series of experiments, be able to construct the*

machine from the description." And on page 72, FRY, Justice, says: "The patentee must state not merely the problem which is to be solved, but the mode of solving it."

See also

Tyler vs. Boston, 7 Wall, 327.
Wood vs. Underhill, 5 How., 1.

Now, the monopoly granted by the patent law is not a gift; it is intended to be a *quid pro quo*. It in effect very seriously limits the freedom which all citizens but for it would have, to make any and every machine, and prosecute any and every industry. It, however, does that only upon the theory that some knowledge and information has, as the equivalent, been given to the public.

In looking at this branch of the subject, we beg the Court to bear in mind the testimony of Mr. Cross, on page 81, in answer to the 44th, 45th and 46th interrogatories, to the effect that at the date of this patent the art of transmitting the characteristic pitch of a musical sound, including the pitch of a sound produced by the voice, was known. The testimony also shows that such art had been availed of in various ways; all multiple-telegraphic, all harmonic-electrical instruments were founded upon it; yet Prof. Cross says that the practical realization of an instrument which could transmit the three characteristics of pitch, intensity and quality of a musical sound would not necessarily have involved the practical realization of the transmission of articulate speech. In other words, an inventor might have availed of some method or process or apparatus for the transmission of these three characteristics of sound, in order to effect, and for the very purpose of effecting, the same results which had been theretofore less satisfactorily effected by instruments which transmitted only pitch. Of course, the more complex the results effected by any instrument, the more available would it be for

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the purposes of multiple-telegraphy, or for any purpose in the way of conveying signals by electricity.

Now, we submit that if Prof. Bell had really, at the date of his patent, discovered or invented the new art of transmitting speech, in contrast to the transmitting of audible signals, he was bound to set it forth fully and clearly and beyond all controversy, so that "he who runs might read." If he has not done so; if, on looking at his patent, any man of ordinary skill in the sciences of acoustics and electricity at the date of the patent would not know that that art had been discovered, and would not know without a series of experiments how to construct the apparatus, and how to use it when constructed, we submit that the patent is void for lack of sufficiency of description. If, on the other hand, Mr. Bell did not know, at the date of his patent, that his so-called "method" or apparatus would transmit articulate speech; if, in other words, he had not then invented the art of transmitting speech, but if he hoped that it might be invented, and if he deliberately used language which by the light of subsequent discoveries and inventions might be held broad enough to cover such subsequent invention or discovery, but which was not in itself sufficiently plain to disclose such invention or discovery to others of ordinary skill in the art, then, we submit that the patent is also void for fraudulent concealment.

Prof. Morton, in testifying on this point, said that there was nothing in the patent 174,465 describing or suggesting the transmission of articulate speech; that what figure 7 did describe and suggest was a singing or non-articulating telephone. Being asked (page 651, cross-question 101):

"Then, you think that when Mr. Bell said that the human voice might be uttered into A, and that a similar sound to that uttered into A might proceed from L, he only meant that to be true in case the human voice was sung, as you understood the entire language?

"A. Beyond a question that and only that is precisely what that phrase means, taken in its existing connection. What Mr. Bell knew at the time is the best test of what he meant. According to his own testimony, as I recollect it, he had never heard a word transmitted through such apparatus at the time this patent was drawn. If, on the other hand, he had succeeded in this direction and knew that the apparatus would operate as a speaking telephone, then I should be unwillingly obliged to conclude that he had deliberately used language intended to conceal what he knew and to mislead the public."

Mr. Park Benjamin, in speaking of the peculiarities of patent 174,465, on page 2123, says:

"From all I can gather from his (Prof. Bell's) testimony, and from his statements in his patent, he seems to have known what had been accomplished in the way of transmitting sound by electricity, and I cannot conceive of anyone having such knowledge deliberately leaving out in a patent the specific reference to a capability of his instrument whereby would have been effected, had it been present, such an enormous advance in the art, or even his leaving the same to be discovered by inference at a later day; and in the list of advantages which I have quoted (referring to the benefits stated by Bell in his patent to be derived from the invention) he makes no mention of this, which would have been immeasurably the greatest of all. He says in his specification that the sinusoidal curve A and B, figure 4, represents graphically the electrical undulations induced in the circuit by the vibration of a body capable of inductive action, and adds nothing to show that he does not intend the curve to represent *all* the vibrations induced, so far as he intended them to be transmitted."

Now, in respect to machines, the law at the date of Bell's patent required the deposit of a model as a condition precedent to the issue of a patent; and when the thing invented is insusceptible of being exhibited by a model, its description must be adequate. When the thing claimed in the patent purports to be a new art, the doing of something which has never before been done in any way, certainly the very highest possible grade of definiteness in specification and description is required. That new art should be expressed in no covert or ambiguous terms; its scope should be clearly defined, and all which is not

thus defined and found to be integral to the new art must be deemed to be abandoned. Applying this rule to the patent 174,465, and treating it as a patent intended to cover the art of transmitting articulate speech, where do we find by designation or description any intimation that the processes there described are applicable to or intended to be applied to that specific thing, the transmission of articulate speech? The patent is described as for an improvement in telegraphy. The specification begins with the statement of the invention of certain new and useful improvements in telegraphy; it recites certain patents and inventions theretofore made by Mr. Bell in the way of multiple-telegraphy; it recites the improvements in the art of multiple-telegraphy which he supposes to be made by the invention there described. He says that the invention consists in the employment of a vibratory or undulatory current of electricity, in contradistinction to a merely intermittent or pulsatory current, and of the method of and apparatus for producing electrical undulation upon a line wire. He sets forth specifically and in detail the advantages which he claims to derive from the use of his invention. They are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that the closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction coils; fourth, that cable despatches may be transmitted more readily (rapidly) than by means of an intermittent current, or by the methods at present in use; fifth, that as the circuit is never broken a spark-arrester becomes unnecessary. He points out no other advantages to flow from the invention in that patent described. He describes, or rather refers to, several of the methods which may be employed for producing undulatory currents of electricity. He then adds that he shall describe one form

of apparatus for producing the effect, and he goes on to describe figure 5 and its combination as figure 6. He then refers to figure 7 as merely "another mode whereby motion can be imparted to the armature by the human voice or by means of a musical instrument." This figure 7 is not described in any other manner, nor is any other reference made to it than as "another mode of imparting motion to the armature" of figure 5, and as to the words, "the human voice," the maxim, "*noscitur a sociis*," applies, *i. e.*, by the human voice used as a musical instrument to create musical vibrations. If it be said that the description states that a sound will be heard to proceed from L similar to that uttered into A, it must also be said that practically the same statement is made with regard to figures 5 and 6, because the inventor says with regard to them that they may be used for the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

It may be argued that if sounds of any kind could be transmitted by figures 5 or 6, then figures 5 or 6 would transmit speech, quite as well, as it can be argued that because in regard to figure 7 it is stated that when the sound is uttered into A a similar sound will be heard to proceed from L, that, therefore, it will transmit speech. Figures 5 and 6 can now be made so as to transmit speech, but surely there is no indication in the patent that the inventor supposed or intended that they might or could be, or to instruct the public that they might or could be, used for such purposes. True, the specification with regard to figure 7 mentions the similarity of form, and the word "form" is not before found in the patent. Although, however, that particular word had not before then been used, yet the same thing had substantially been said when the patent told us that electrical undulations produced by the vibration of a body capable of inductive action could be represented

graphically without error by the same sinusoidal curve which expressed the vibration of the inducing body itself, and that electrical undulations result from gradual changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. When in relation to figures 5 and 6 he told us that the electrical action could be represented by the same curve, and was represented by the same curve which represented the action of the inducing body, he substantially said that the two curves were similar in form. Mr. Pope Dowd, Record, 333; Overland, 3118, Ans. 21, says: "The term 'form of vibration,' when used in the scientific sense, I understand to refer to the form by which these vibrations may be properly and correctly represented graphically—that is, by diagram." There is nothing in the patent to indicate that the similarity in form referred to in respect of figure 7 is in any degree different from the similarity in form referred to in respect of figures 5 and 6. Was not the inventor bound in common fairness and honesty to state clearly, if he so meant it, that the form here referred to was other and different than the similarity of graphic representation before referred to? And can it be said that the inventor complied with the rule of clearness and perspicacity when, instead of definitely saying that this figure 7 was calculated to transmit speech, he simply pointed it out as another mode of vibrating the armature of figure 5?

That the inventor did not feel that his description of Fig. 7 was sufficient for the purpose, is apparent from the very different description he gives of these instruments as improved in his patent 186,787 and in his English patent. In both of these patents he describes the sound heard at the receiver as the *fac simile* of that made at the transmitter—not as "similar in form," and adds that "hence" it is adapted to transmit speech.

Assuming that this great discovery of the art of transmitting speech is to be found in this patent, why

should the public be left to dig it out by inference and deduction in this manner? Why should the patentee claim the benefits of the monopoly on his side, when he has failed in clear, precise and express language to divulge to the public the art for which he claims the monopoly? When Mr. Bell had the idea clearly in his mind, he was able enough clearly to express it. In his patent of 1877 and in his English patent there is no doubt or obscurity in the description; speech is clearly and in terms described. Why should the public be left to grope in the dark at the time of the original and great invention, when they are taken in hand and led with light of the clearest brilliancy in respect of the more detailed inventions described in the subsequent patents?

The reason is tolerably clear. Either Mr. Bell has not described and did not intend to describe anything like the transmission of speech in his first patent and merely intended figure 7 as in his patent he has described it, as another mode of imparting motion to the armature, or else, as Prof. Morton says, he deliberately intended under vague general terms to include something which he had not yet invented, which not being clear in his own mind he could not disclose to the public, but which he hoped under the guise of a principle to secure to himself and to cover whatever means or method for applying it might be subsequently invented either by himself or by others. He was like Galileo when he first saw, as he thought, that Saturn consisted of three spheres close together, the middle one being the largest. He was not quite sure of the fact and was in a dilemma between his desire to wait longer for further observation and the fear that some other observer might announce the discovery if he hesitated. To combine these incompatibles, to announce it so as to secure the priority, and yet not to announce it until he was ready, might seem to present as great a difficulty as the discovery itself; but Galileo solved it, as

would be to block the path to all future progress in the line of milling."

We may add here, that if this had been known as Mr. Bell's invention, and that the existence of this patent would cut off where it stood all future progress in the art of transmitting speech, and if we assume that all men were guided by the same practical business principles which actuated Mr. Bell in securing for himself the practical results of his inventions rather than the mere acquisition of scientific fame—the microphone, the Blake transmitter and all other improvements whereby the telephone of to-day has become a practically beneficent thing for human intercourse and convenience, would never have been invented. Why should we go on and invent and improve, these men would say, when Mr. Bell, by means of this vague description which he has given, can stop the use of our inventions? The field of invention would have been given over exclusively to Mr. Bell, and on him alone we should have had to depend. When the time of his patent had expired, we would have been in the same condition of blissful ignorance as to what to do with figure 7 as Mr. Bell and Mr. Watson were at the time the specification of Patent 174,465 was filed.

Fourth.

The Defendants do not Infringe.

The attention of the Court is called to the peculiar character of the defendant's transmitter. A drawing of it is shown on page 156 of the record. It consists of the hub of a carbon-wheel with eight carbon spokes. The spokes consist of rods of carbon fitting loosely into sockets in the hub and into sockets in carbon blocks at

the outer end. Four of such carbon blocks at the outer ends on each said are connected by a strip of copper. The whole is fastened to a piece of sheet-cork, or other non-resonant material. To one of these strips of copper a wire connecting with the positive-pole of the battery is connected, and to the other the wire connecting with the negative pole. The current passes into one of the strips of copper through each of the spokes into the hub, into the corresponding spokes and into the other strip of copper and into the wire. As one speaks against that cork it is jarred or shaken, molecularly or otherwise, and the several carbon-rods on each side are affected by such jarring or shaking in such manner that the voltaic current passing through this circuit so affects the magneto-receiver at another point on the circuit that speech is produced. How it so effects the result no person can tell. It is all very well to say that by increase or diminution of the current passing through these spokes of carbon electrical undulations are produced corresponding to the air waves; that does not give us any notion whatever as to what takes place. We are not one hair's breadth further advanced than when we say that by speaking to the cork diaphragm such result is produced that one stationed at the receiver hears. A number of experts whom we have examined—Prof. Morton, Prof. Blackett, Prof. Channing, Prof. Young, and others—say that it is impossible to tell what takes place in the wire, or by what means speech is actually produced. They all say that in all probability there is more or less rupture of contact; or, in other words, more or less make and break of the electrical current passing through the spokes of the wheel. That the electric current is wholly broken so that no current is passing along the whole line may not be true; and yet who can say that it is not? That the result may be produced by the actual rupture and complete break of the current, say through one of the spokes or through a portion

would be to block the path to all future progress in the line of milling."

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of one of the spokes, or by the breaking or joining of more or less of any of the minute points of contact which exist upon surfaces when, in common language, we say that they are joined together, is, in the opinion of these experts, quite probable. That such rupture and joining, or such variations of pressure, should produce speech, that in the many thousands or millions of points of contact which exist in these several spokes at the hub and at the ends the increase or diminution of the whole current should be just such as is necessary in order to reproduce the speech, is in the present state of our knowledge a completely unfathomable mystery.

On page 660 Prof. Morton was asked, cross-interrogatory 130:

"Is there any substantial difference in principle or mode of operation between the transmitter of the defendants in this case and the transmitter in the Spencer case, or the Blake transmitter, so called?

"A. As to the identity or similarity between the structure and mode of operation of the transmitter referred to as 'Defendant's Transmitter' and the Spencer and Blake transmitters, I can only say that in structure defendant's transmitter is entirely unlike the others, and as regards its mode of operation I do not feel myself able to say with any certainty exactly what that mode is. When I first saw this transmitter, the impression it produced upon my mind was that, had I not been informed under circumstances that compelled my belief that it was operative, I should have felt very confident that it was not, and except to convince myself by actual trial that it was operative, I have made no examination of it which would enable me to say with certainty how it does operate. *The fact that it does operate at all is, in my opinion, as surprising as anything connected with the subject of telephone transmission.*

"Q. Don't you think you are able to say, upon reflection, that each of the spokes of that transmitter is an ordinary Hughes microphone as commonly shown in the books on electricity?

"In form, yes; in operation it seems to me not, because, if each of them acted independently, it would appear to me necessary that one would destroy the effect of the other, and that the effect of their multiplication would simply be to destroy the operativeness of the apparatus.

"136 Q. And is not the effect produced, for the purposes of a transmitter, by the variation of pressure between the points of

contact, produced by the vibration of the diaphragm supporting those points of contact?

"A. It may be, but my impression is that it is produced rather by *numerous minute ruptures occasioned* at different parts of the countless contact points of this apparatus than by the changes of pressure only.

"137 Q. Then, you mean to say, as I understand you, that perhaps this apparatus is a circuit-breaker and interrupts the current, whereas the Blake transmitter maintains a continuous current?

"A. I do. I consider this to be very possibly the mode of action of this transmitter.

"138 Q. Do you believe it to be true that this transmitter makes and breaks the electric current, whereas the Blake transmitter does not?

"A. I believe that this transmitter makes and breaks the current at numerous points during its operation, though I do not think that it interrupts the entire current or interrupts the current everywhere at any one time. In the Blake transmitter it is my impression that there is never any rupture or renewal of contact, but that there is simply a variation in the minute distance, probably something *less than a two thousandths* of an inch, by which the electrodes are separated, such separation being consistent with what we know as mechanical contact; in other words, we say two bodies are mechanically in contact when they are separated, as a matter of fact, by a distance not greater than one 2000ths of an inch, and it is my belief that the action of the Bell transmitter depends upon the motions of approach and recession between the electrodes included within this distance."

A mode of operation of which the Court will remember, Mr. Bell, according to his preliminary statement in the interference cases (page 2078), was ignorant.

Professors Channing, Brackett, Young and others all express themselves as believing it quite possible, and certainly not proved to the contrary, that the action of the microphone consists in this minute making and breaking of different points of contact. Prof. Channing, on page 581, Answer 106, says:

"It is desirable that there should be no makes or breaks occupying the space of a single vibration of the diaphragm. Various devices are used, patented and unpatented, to prevent such breaks; this does not apply to the lesser arrests or reversals of motion, which I think are concerned of the function of articulation. I will add, for the sake of accuracy, that in the class to which the exhibit 'De-

fendant's Transmitter' belongs, the microphone action seems to consist in innumerable makes and breaks, the aggregate effect of which is the abrupt changes represented in the tracings of Prof. Blake."

Prof Brackett says (page 491–2, Answer 179):

"The difficulty in rendering a simple and direct answer arises from the fact that we are yet in ignorance as to the precise mode in which the successful operation of this instrument occurs (referring to microphone instruments)."

Asked whom he includes in the term "we," he answers:

"I include in the term 'we' the general consensus of scientific men in this and other countries, and as evidence of the state of ignorance on that matter, I call attention to the fact that a large number of ingenious experiments have been contrived and executed with a view to determine that point, but with, so far as I know, no satisfactory or undisputed results. The theoretical discussions that have from time to time appeared have taken the widest ranges and have been carried on in apparent candor by gentlemen who cannot be supposed to have any other than purely scientific interest in their decision; for instance, in the text-books on General Physics recently appearing in Germany, by Mousson, we have a short summary of the views that have been presented, with the question still left in abeyance. I do not cite the controversies which have taken place evidently in the interest of inventors and companies, either in our own country or abroad; I do, however, say that very much of reasonable support for either view can be adduced from undisputed principles of electrical science, as well as from principles of acoustical science."

On page 577 Prof. Channing is asked:

"Q. Then you mean to say, do you, that microphone transmission as now understood in fact amounts to an interruption of the current; or, as Reis puts it in his articles describing his operation, 'the current traversing the strip is broken; * * * in this way each sound-wave causes a *breaking and closing* of the circuit?'

"A. *I don't know how the very complex subject of microphone transmission is understood in the sense of general agreement. It is a subject still under discussion.* I have already stated in detail my reasons for believing that the elements of articulation in microphone transmission may be introduced by minute interruption within the

limits of a single vibration. This is not the kind of interruption of current referred to by Reis in the quotation contained in the question."

If this difference between the kind of interruption in the microphone referred to by Prof. Channing and also by the other experts, and that in the Reis instruments, were of such broad generic character as to prevent the Reis instruments being an anticipation of the modern telephone, it surely does not prevent the principle and operation of the microphone being wholly and completely different from that of the magneto instruments described by Mr. Bell. We may assume that *they* (the magneto and the microphone) produce the same effect; but if it be true, or if it may be true for all that we know, that the microphone produces this effect by means of minute makes and breaks, then, surely it is another and different method of producing the result from that of the magneto method which produces its effects without any make or break, and by creating an electric current through the action of the voice.

The same view which is taken by our experts may also be found in scientific treatises of a very late date. In Ganot's treatise (which is a standard French publication of the very highest authority), in the 11th New York edition translated by Prof. Atkinson, page 100, may be found this passage:

"This theory of a telephone with a disk of soft iron is not complete. The vibrations of the vibrating disk do not appear to be due solely to the magnetic variations of the magnet. The measure of the intensity of the induced currents in the Bell telephone certainly proves that they are a great deal *too feeble* to produce vibrations of the disc simply by magnetic attractions and repulsions. Moreover, *if non-magnetic discs of glass, copper, wood, etc.*, are substituted for a disk of soft iron, the sound will be transmitted still, though with much less intensity. Without rejecting the induced currents which are developed in the bobbins by the induction of the disk of soft iron of the transmitter, one is therefore led to admit, besides, that the box of the telephone and the magnetic bar themselves enter into vibrations under the influence of the voice, and that their mole-

fendant's Transmitter' belongs, the microphone action seems to consist in innumerable makes and breaks, the aggregate effect of which is the abrupt changes represented in the tracings of Prof. Blake."

Prof Brackett says (page 491–2, Answer 179):

"The difficulty in rendering a simple and direct answer arises from the fact that we are yet in ignorance as to the precise mode in which the successful operation of this instrument occurs (referring to microphone instruments)."

Asked whom he includes in the term "we," he answers:

"I include in the term 'we' the general consensus of scientific men in this and other countries, and as evidence of the state of ignorance on that matter, I call attention to the fact that a large number of ingenious experiments have been contrived and executed with a view to determine that point, but with, so far as I know, no satisfactory or undisputed results. The theoretical discussions that have from time to time appeared have taken the widest ranges and have been carried on in apparent candor by gentlemen who cannot be supposed to have any other than purely scientific interest in their decision; for instance, in the text-books on General Physics recently appearing in Germany, by Mousson, we have a short summary of the views that have been presented, with the question still left in abeyance. I do not cite the controversies which have taken place evidently in the interest of inventors and companies, either in our own country or abroad; I do, however, say that very much of reasonable support for either view can be adduced from undisputed principles of electrical science, as well as from principles of acoustical science."

On page 577 Prof. Channing is asked:

"Q. Then you mean to say, do you, that microphone transmission as now understood in fact amounts to an interruption of the current; or, as Reis puts it in his articles describing his operation, 'the current traversing the strip is broken; * * * in this way each sound-wave causes a *breaking and closing* of the circuit?'

"A. *I don't know how the very complex subject of microphone transmission is understood in the sense of general agreement. It is a subject still under discussion.* I have already stated in detail my reasons for believing that the elements of articulation in microphone transmission may be introduced by minute interruption within the

limits of a single vibration. This is not the kind of interruption of current referred to by Reis in the quotation contained in the question."

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cular vibrations are transmitted by the copper wires to the case of the receiver. Upon the whole, the actions and reactions of which the telephone is the seat are not so simple as was at first thought, it may be said that the theory of this instrument is yet to be made."

In the modern applications of electricity by E. Hospitalier, volume page the same opinion is expressed, and in "Electricity and Magnetism" by Fleming Jenkin, page the same views are also expressed.

Can a judgment of this Court that we infringe the patent of Mr. Bell be founded upon a mathematical conception, the application of which to his invention or to the devices used by the defendants is thus doubted by men of the highest character and attainments? It is bad enough, in all reason, to complain of our infringing his monopoly of a mathematical conception, but when to that is added a doubt by the highest authorities of the accuracy of that mathematical conception as applied to the operation of his machine, the case is carried far beyond any heretofore recognized limit of patentable methods or processes.

In a little book called "Notes on Physics," by J. A. Gillet, published in 1876 in New York, by Potter, Ainsworth & Company, it is said that there are three classified units of matter denominated the *molar*, *molecular* and *atomic*, and that there are three great forces of nature, *gravity*, *cohesion* and *affinity*, the first being a molar force, the second a molecular force and the third an atomic force; that work is the overcoming of resistance through space, and that the ability of a body to do work is called *energy*. The writer then adds: "It is doubtful whether electricity is a force or an energy."

And yet in this patent the monopoly is claimed for effecting undulations similar in form in something which certainly cannot be called a substance, as it is not matter (and who can predicate undulations without matter?), and which, if either a force or an energy, is

something of and in respect to which undulations cannot be conceived.

In the December, 1886, number of the "Fortnightly Review," Prof. Huxley writes an article defending himself against the imputation made by Mr. Lily in the November number of the same review, that he (Prof. Huxley) was a materialist. On page 794, referring to the terms "force and matter and atoms," &c., he says:

> "I must make a confession, even if it be humiliating. I have never been able to form the slightest conception of those 'forces' which the materialists talk about as if they had samples of them many years in bottles. They tell me that matter consists of atoms which are separated by a mere space devoid of contents, and that through this void radiate the attractive and repulsive forces whereby the atoms affect one another. If anybody can clearly conceive the nature of these things which not only exist in nothingness, but pull and push there with great vigor, I envy him for the possession of an intellect of larger grasp, not only than mine, but than that of Leibnitz or of Newton. * * * Besides, by the hypothesis the forces are not matter: thus all that is of any particular consequence in the world turns out to be not matter, on the materialist's own showing. Let it not be supposed that I am casting a doubt upon the propriety of the employment of the terms 'atom' and 'force' as they stand among the working *hypotheses* of physical science. As formulae which can be applied with perfect precision and great convenience in the interpretation of nature their value is incalculable; but as real entities having an objective existence, an indivisible particle which nevertheless occupies space is surely inconceivable; and with respect to the operation of that atom where it is by the aid of a force resident in nothingness, I am as little able to imagine it as I fancy any one else is."

And yet Prof. Bell would have the Court not only erect these formulæ into an absolute conceivable existence, but would call them by the name of process—would regard them as practicable, workable and described means for producing desired results, intelligible to and acted on by ordinary workmen and mechanics, and of such character that, if anybody, in explaining the operation of a machine, refers to these undulations as a scientific hypothesis which may explain the work-

ing of such machine, it is conclusive evidence of the infringement of his patent.

Now, the Court will note that the question of infringement here is in no degree connected with the apparatus shown in figure 7. Complainant's expert as well as defendants' experts agree in saying that the apparatus used by the defendants is wholly different from that shown in the patent. The one and only point whereon infringement is claimed is that the general mode of operation of the two instruments, or of the apparatus used by the defendants and that shown in figure 7, can be explained by the same "mathematical conception" or by the same "working hypothesis" that explains that of figure 7. If that be law, can any one say why any apparatus whatever, the operation of which is explained by the application of the several forces known as gravity, cohesion or affinity shall not infringe upon any other apparatus described in a prior patent wherein the inventor shall say that what he claimed is *the method* of operation of the apparatus which is that of gravity, cohesion or affinity?

Some slight idea of the phenomena taking place in a magneto-telephone may be gathered from the fact that the diaphragm being under control of the voice creates currents of electricity as it is moved forward or drawn back, which absolutely owe their existence to the voice and which cease to exist with the cessation of the voice. But comprehension of that operation gives us no idea whatever how such a device as that used by the defendant can, by the joggling of sixteen different joints spaced upon various parts of a large cork diaphragm having a diameter of six or eight inches and a thickness of a quarter to three-eighths of an inch, so affect a voltaic current passing through the carbon spokes that it will so affect the receiver as to cause similar air vibrations to those which are impressed against the cork diaphragm.

Defendant's instrument is called a microphone, and

in a general sense it may be properly so called. That the microphone is an invention of the highest character is not controverted. Prof. Bell, in the Preece discussion (Record, page 249), says: "No one can more "heartily congratulate Prof. Hughes upon his *great* "*discovery* than I do." Discovery is hardly the term to apply to a mere varied mechanism for carrying into effect a principle or idea which Prof. Bell had himself discovered. This Court has rather regarded discovery as the basis of, and antedating, a process (Corning vs. Burden, 15 How., 252). In speaking of this invention, Mr. Hughes says (Record, page 218): "I do not intend to take "out a patent, as the effects I have mentioned belong "more to the domain of *discovery* than invention. No "doubt invention will ere long improve on the form "and materials employed."

On page 219 he says :

"The *problem* which the microphone solved is this—to introduce into an electrical circuit an electrical resistance, which resistance shall vary in exact accordance with sonorous vibrations, so as to produce an undulatory current of electricity from a constant source, whose wave length, height and form shall be an exact representation of the sonorous waves. The second step is of the highest importance. It is essential that the electrical current flowing be thrown into waves of determinate form by the sole action of the sonorous vibrations. I resolved this by the *discovery* that when electric conducting matter in a divided state, either in the form of powder filings or surfaces, is put under a somewhat slight pressure, far less than that which would produce cohesion and more than would allow it to be separated by sonorous vibrations, the following state of things occurs—the molecules at these surfaces being in a comparatively free state, although electrically joined, do of themselves so arrange their form, their number in contact or their pressure (by increased size or orbit of revolution) that the increase and decrease of electrical resistance of the circuit is altered in a very remarkable manner, so much *so as to be almost fabulous.* The tramp of a fly, or the cry of an insect, requires little range, but great sensitiveness; and two surfaces therefore of chosen materials under a very slight pressure such as the mere weight of a small superposed conductor, suffice; but it would be unsuitable for a man's voice, as the vibrations would be too powerful and would, in fact, *go so far* beyond the legitimate

range, that *interruptions of contact amounting* to the well known make and break would be produced."

The attention of the Court is called to the use of the word "interruption" as meaning less than a complete break in a telegraphic sense, which is the meaning we have argued it has in the Reis articles.

On pages 222 and 223 Mr. Preece says:

"In fact, there must have been a movement to a certain depth, and I am inclined to believe, from numerous experiments, that the *whole block increases and diminishes in size at all points, in the centre as well as the surface, exactly in accordance with the form of the sonorous wave.* Confining our attention, however, to points on A and B, how can this increased molecular size or form produce a change in the electrical waves? This may happen in two ways: First, by increased pressure on the upper surface, due to its enlargement; or, second, the molecules themselves, finding a certain resistance to their ordinary movement, spread themselves, *making innumerable fresh points of contact.* Thus, the undulatory current would appear to be produced by infinite change in the number of fresh contacts. I am inclined to believe that both actions occur, but the latter seems the true explanation. For, if the first were alone true, we should have a far greater effect from metal powdered carbon or some other elastic conductor, such as metallized silk, than from gold or other hard unoxidizable matter; but as the best results as regards the human voice were obtained from two surfaces of solid gold, I am inclined to view with more favor the idea that *an infinite variety of fresh contacts brought into play by the molecular pressure affords the true explanation.* It has the advantage of being supported by the numerous forms of microphone I have constructed, in all of which I can fully trace the effect."

On page 240 Mr. Preece says:

"In this transmitter one of its chief peculiarities is the fact that all sounds are faithfully reproduced, and it tends very much to upset the notion—Helmholtz's—theory, that vowel sounds and other sounds are due to the superposition of waves upon waves, of tones and over-tones. This apparatus shows almost unquestionably that all these different properties and these effects of intonation are due to differences in the form of the wave sent."

On page 242:

"No one has ever been nearer a great discovery than Mr.

Edison. His telephone is based on the variation of resistance in carbon due to pressure. He used carbon and finely divided matter, but he worked on the idea that the difference in pressure was produced by the vibration of a diaphragm. Had he thrown away his diaphragm, he would have forestalled Professor Hughes in this respect, and found that the sonorous vibrations themselves produced this difference of pressure. The great secret of Professor Hughes' discovery is that sonorous vibrations and electrical waves are to a certain extent *synonomous.*"

In the discussion following Mr. Preece's reading, Mr. Willoughby Smith was inclined to reject Mr. Preece's molecular and sound-wave theory of microphone, and to attribute the phenomena to a partial breaking of the circuit by the varying contact (p. 249). Now, it was in reference to this discovery that Professor Bell was speaking as above, and we call the attention of the Court to what he said. He says (p. 249):

"No one can more heartily congratulate Professor Hughes upon his *great discovery than I* do. I think all those who investigate telephonic effects will realize that we have touched upon the threshhold *of a new science*, and that we have discoveries yet in store for us. I must confess that the explanation of the action of the microphone afforded by Mr. Preece and Mr. Willoughby Smith are, to my mind, not perfectly satisfactory. There are some points in the telephone itself that *may* point us to the true solution of this problem. If you fix your attention on the first diaphragm shown us by Mr. Preece, you have a constant source of electricity (the battery), a telephone, and this curious instrument. Now, the laws of audibility of the electric current by the telephone are analogous to the laws of induction. No sound is audible so long as your current is of uniform intensity, but the moment you change its intensity you have a sound from the telephone; conversely, when you have a sound from a telephone the intensity of the current passing through it has been changed, and the loudness of the sound is an index of the amount of change.

"Now, unless the microphone *were itself a source of electricity*, it is evident that the only way in which it can change the current is by varying the resistance of the circuit. So far, we may be perfectly certain that the action of this instrument depends upon the variation of the resistance; and the only question is as to how this variation of resistance can be accomplished by the influence of such feeble sounds as those produced by the escapement of a watch or

the footsteps of a fly. As the sounds produced from the telephone are quite loud the current *must change very greatly* in intensity, and the resistance of the microphone *must vary in the most extraordinary manner*, probably being at its maximum many times the resistance of the rest of the circuit, and at its minimum but a fraction of it. Mr. Preece seems to consider that the molecules of the substance composing the microphone change their shapes when subjected to compression by a variable force; and he has figured to us his conception of the alternate contraction and expansion of a chain of molecules under the influence of sound. Mr. Willoughby Smith, on the other hand, attributes the effects produced by the microphone to imperfect contact. He supposes the carbon points *to rattle against one another* under the influence of a sound, and he seems thus to regard the microphone as a delicate form of *interrupter*."

We again call the attention of the Court to this use of the word "interrupter" by Mr. Bell himself.

"I am more inclined to accept Mr. Willoughby Smith's explanation than that given us by Mr. Preece, but the reproduction of articulate speech excludes the assumption that the microphone acts as an interrupter. The possibility of producing electrically any given quality of sound depends upon the possibility of producing a current of electricity, the intensity of which varies in a manner proportional to the varying velocity of a particle of air during the production of that sound. Hence, however much the points in contact may rattle together, the circuit must not be broken, or the effect of quality will be lost, and a mere noise be produced instead."

"If I might offer a suggestion, I think it probable that there is a variation in the amount of contact. Let us suppose an enormous number of particles to be in contact, each singly offering a high resistance to the passage of a current, but jointly offering a very slight resistance; then, when the microphone *rattles under the influence* of a sound, a larger or smaller number of particles come into contact, and the resistance of the microphone changes without absolute break of circuit. Still we must not forget that at each increase of resistance *heat must* be produced at the points of contact, and it is probable—nay, extremely likely, that heat has a great deal to do with the results obtained. I was experimenting with a microphone the other day, and it kept on vibrating on its own account for nearly two minutes, and a clear musical tone was emitted from the telephone in circuit with it. The microphone always exhibits a tendency towards vibrating on its own account when it is adjusted most delicately. The instrument, as I constructed it, consisted of a rod of charcoal placed horizontally with its ends resting

upon two other rods of charcoal. This arrangement, when shown to Professor De Warr at once suggested to his mind Trevelyan's bars. I think it not at all unlikely that the microphone is in reality a species of Trevelyan's rocker, and that it may thus be in a condition to be affected by feeble sounds. It is quite conceivable that sounds too weak by themselves to throw the masses of the microphone into sensible vibration may yet be sufficiently strong to vary and control the variations *due to heat;* or at least it is conceivable that *heat may* assist the action of the sound. For instance, suppose the charcoal *rattling together* under the influence of the sound. Now, as the charcoal separates, the resistance of the microphone increases, the points of contact *become heated, and the expansion, due to this cause, occasions* a greater separation than would otherwise take place. *Thus heat may co-operate* with a feeble sound to produce a greater amplitude of vibration at the points of contact than would be produced by the sound alone. Those who are interested in this subject would do well to read Professor Page's paper upon 'the vibrations of Trevelyan's bars by the galvanic currents.' The microphone recalls vividly to my mind some of the illustrations in this paper. *Whatever may be the true explanation* of the effects produced by the microphone, there is evidently a vast field open before us for inquiry. I will not take up your time with any further remarks, but will again offer my congratulations to Professor Hughes upon his discovery."

If the Court will look at Prescott's speaking telephone, electric light, &c., published in 1879, pages 114 and 115, it will see what is the Trevelyan's rocker, the substance of which Mr. Bell calls the microphone.

Now, let us look for a moment at the operation of a Bell telephone of 1876. The statement in the patent and the evident idea of the patentee, are that undulations in a voltaic current are produced. The patent says:

"Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action. * * * So long as the armature *c* remains at rest, no effect is produced upon the voltaic current; but the moment it is set in vibration to produce its musical note, powerful inductive action takes place, and electrical undulations traverse the circuit."

That Professor Bell was wrong in this, and that such vibration of the armature is without effect on the vol-

taic current, and that the battery and voltaic current have no function in the operation further than to magnetize the electro-magnet, are now common knowledge. Professor Cross says so (see Complainant's Record, page 127, Cross-question 38): True, Professor Cross attempts to show in a sense that undulations are produced in the voltaic current by stating that the voltaic and magneto currents unite, making but one current. The defendant's experts have shown the fallacy of this statement in that the effect produced is wholly that of and due to the magneto current, and that this magneto current produces precisely the same effect, no more and no less, in the absence of the voltaic current, when the apparatus has only a permanent magnet, and in the presence of the voltaic current when the magneto current works in and through the voltaic current, but not influencing it or influenced by it. Professor Morton (Record, p. 349) says:

"In the apparatus of the Bell patent, I find as a transmitter what may be called a magneto-electric machine, identical in its general structure and operation with other magneto-electric machines which have been used for other purposes; such, for instance, as the apparatus for firing blasts by the sudden withdrawal of an armature from the face of a magnet carrying coils of wire on its poles. In this case the battery current is in no way directly affected by the motion of the diaphragm, which, on the other hand, produces a magneto-electric effect and momentary current in one direction or the other, according to the movement of the armature connected with it."

And on page 353, interrogatory 23:

"I understand you to say that the acting cause in the Bell apparatus 174,465 is the magneto current. Does the voltaic current in that apparatus have any operation or effect upon the diaphragm of the receiver?

"A. None; in the act of transmitting sounds it simply causes a constant pull or tension such as might be occasioned by a spring or the like, and which may be considered as constituting part of the adjustment of the instrument.

"Interrogatory 24. In the defendant's instruments, Exhibit

Defendant's Transmitters and Exhibit Defendant's Receiver, is there any other electric cause of the effect produced on the receiver in the way of transmitting speech than the voltaic current?

"A. There is none other if we neglect the interposition of an induction coil used simply to give greater intensity to the transmitting current.

"Interrogatory 25. Then, I understand you to say that the effect in Exhibit 'Defendant's Transmitter and Exhibit Defendant's Receiver' is produced by varying the resistances of the voltaic circuit, while in the Bell instrument it is produced by the magneto current. Am I correct?

"A. You are; though I should perhaps rather say that in the Bell apparatus the effect was produced by the *production* of a magneto current or currents. This modification of phraseology, I think, brings out more strongly the difference which exists between these two forms of apparatus and their modes of operation."

Professor Brackett says (pages 360, 361):

"Interrogatory 9. In the Bell apparatus as described in patent 174,465, has the voltaic current any other function than that of magnetizing the electro-magnet?

"A. It has not.

"Interrogatory 10. Has it any function in the transmission of speech?

"A. It has not; as may be shown by replacing the electro-magnets by permanent magnets.

"Interrogatory 11. In the instrument Exhibit 'Defendant's Transmitter' and 'Defendant's Receiver,' is there any other electric cause for the effect produced at the receiver than the voltaic current?

"A. There is no other cause.

"Interrogatory 12. Practically, then, in the transmission of speech, do instruments described in the Bell patent 174,465 cause undulations in a voltaic current?

"A. If the question refers to the current constituting the electro-magnets the answer must be that the only effect is to superpose upon the line currents due to the motion of the armature, which by induction react upon the coils to produce *de novo* entirely new currents which are felt as disturbances at the receiving end.

"Interrogatory 13. Does the Exhibit 'Defendant's Transmitter' so operate as to cause undulations in the voltaic current, through the cause of the transmission of speech and its being heard at the receiver?

"A. It does, by controlling the intensity of the current which results from a constant electro-motive force at the battery."

Professor Channing (page 307) says:

"Interrogatory 7. In the Bell apparatus, as described in patent 174,465, has the voltaic current any other function than that of magnetizing an electro-magnet?

"A. It has not; that is distinctly so stated by Du Moncel.

"Interrogatory 8. Has it any function in the transmission of speech?

"A. None, whatsoever, except in magnetizing the magnet where an electro-magnet is used.

"Interrogatory 9. In patent 174,465, and in figure 7, as there shown, may the electro-magnets be replaced by permanent magnets and the same effects be produced?

"A. The electro-magnets could be so replaced, and the same effects would be produced."

The method of the Bell telephone, then, is to produce an electric current in a line wire by approaching to and withdrawing from the poles of the magnet, the coil of which forms part of the line, an armature moved by a diaphragm to which it is attached. When this diaphragm is still, there is no current on the line; in other words, in motion it makes, in quiet it breaks the current. The so-called undulatory character of the current is derived simply and solely from the character of the motion of the diaphragm and armature. According as the latter is sudden, abrupt, gradual, regular, irregular or otherwise, so will be the character of the current produced. We are told by the patent how to vary the force, *i. e.*, the electro-motive force, by making an armature move with the diaphragm, and that the sound may thus be controlled. There is a suggestion not however referring to figure 7 or claim 5 that undulatory currents may also be produced by varying the resistence of a circuit, but the complainant's experts admit that the patent shows no practical means of so doing (Drawbaugh Record, Complainant's Case, Vol. II., pages 1474–1475, Answer 300, 301, original paging).

Mr. Pope, complainant's expert, testified that when he made the report to Mr. Orton in 1877, the liquid transmitter was a thing unknown to him, although he

was then familiar with the Bell patents, and that the description in Bell's patent of March 7th, 1876, is not sufficient to enable a person skilled in the art to make, without further experiments, a practically operative speaking telephone transmitter on that principle. Indeed, in his patent, Bell did not first tell us of the use of an undulatory current for telegraphic purposes ; that surely had been done by Varley ; nor of the use of a vibrating diaphragm transmitting sound waves ; that surely had been done by Reis and Wright ; nor of a magneto receiver with vibrating armature to reproduce whatever was sent from the transmitter ; that surely had been done by Reis and Gray ; nor of electrical effects in a closed circuit ; that surely had been done by Varley and Gray. What Bell did, was simply and solely to adapt the apparatus of Reis to the production of varying electro-motive force, instead of to the variation of a constant electro-motive force ; and his method or the functions of his apparatus consist solely in the production by the vibration of a diaphragm, of a varying electro-motive force, instead of producing variations in a constant electro-motive force. True, Bell supposed, or said he supposed, that he undulated the voltaic current ; in that he was mistaken, and his method and apparatus are simply as above stated. Bell did not tell us in his patent or otherwise, for he did not know, that by inserting three French nails, or three pieces of carbon, in a voltaic circuit, sounds of all kinds could be transmitted to a distant receiver, or that by vibrating a portion of the circuit by sound waves, its nature could be so varied as to reproduce sounds at the receiving end of the line. He did not tell us, for he did not know, that in some obscure way the electric current responds to vibrations that may be caused in any part of its conductor, though infinitely small in character, and will transmit such vibrations to a receiver, and that in that way articulate or other sounds can be almost perfectly

reproduced. More than all, Professor Bell did not tell us, because he did not know, that with proper modifications of his apparatus, figure 7, or with a properly arranged microphone, articulate speech could be transmitted—indeed, if he judged from his own experiments and trials, he knew that it could not. And yet, when these effects are discovered and the appropriate apparatus is invented, Bell modestly claims monopoly of the whole, because he faintly and obscurely indicated a mageto machine as a form of multiple telegraphing, which he knew by experiment would not work, and from the description of which he struck out the words which would have characterized it as an apparatus intended to transmit speech.

Professor Cross says that the microphone infringes the magneto-telephone, because it excites electrical undulations on a line wire, and he knows that it does that because it talks. Why he bothers himself and us with this middle term as to electrical undulations, as to which no one has any knowledge or offers, or can offer, anything but theory, and did not say directly —it infringes because it talks, we cannot conceive. Indeed, in his last testimeny he has eliminated the middle term and says that an instrument operates on the Bell or Reis method according as it talks or not, and that the only test whether it is a Bell or a Reis is whether it will talk. It is shorter and quite as conclusive. One may admit that the term "undulatory" has a certain appropriateness when applied to electrical impulses generated by the vibratory to-and-fro motion of a diaphragm; but how does it apply to or describe the mere joggle or shaking produced by speaking to a piece of non-resonant cork to which is firmly attached a carbon microphone device like that of the defendant's transmitter? The following extract is from the "Electrical Review" of January 24th, 1885, and we adopt it as an argument:

[From the "Electrical Review" of January 24th, 1885.]

An Undulatory Current in a Closed Circuit not necessary for Telephonic Transmission of Articulate Speech.

My attention has been called to two papers on this subject signed "Das Telephon," published in your excellent Review of February 2d and 9th, 1884, in which are given extracts from affidavits of several eminent American physicists, namely, Profs. Morton. Mayer, Cross, Wright, Wagner and others, all of whom testified that articulate speech has been transmitted and reproduced in rapidly interrupted electric circuits. I invite those interested to read the papers referred to. Copies of the affidavits have been kindly sent to me since my communication on this subject in the "Review" of 3d inst. The theory of Profs. Cross and Wright is fully proven by the experiments made by me as detailed in my communication above referred to. I shall be pleased to lend to any one those affidavits, and I invite the editors of "La Lumiere Electrique" to reconsider their statement, published in November, 1882, that "As to the question of knowing whether currents completely interrupted can reproduce speech, there is no electrican who can answer it."

I invite them to repeat the experiment described by me, and then abandon their pet theory about the undulatory currents being absolutely necessary for the transmission of articulate speech. That a closed circuit is not necessary for such a purpose my numerous experiments have conclusively proved, and I will add that undulations of the current corresponding to the undulations of the air waves produced by the voice seem to me to exist more in theory than in practice.

In all transmitters heretofore known the sound waves fall upon what may be termed a current regulator; either directly or through the medium of a tympan or diaphragm, whereby greater or less pressure is made

upon the loose joints of the current regulator, producing a motion corresponding in its movement to the vibrations of the air waves, which is an up-and-down motion—a vibratory motion—and the increase or diminution of the current is caused by the greater or less pressure of the parts of the current regulator against one another, being the principle of the action of transmitter claimed by Edison. Now, I have for several months past been experimenting with a novel form of Hughes' beautiful invention—the carbon microphone. This microphone is made of hard carbon pencils, without top, bottom or sides, but simply held together by a frame not more than an eighth of an inch wide; loose pencils lie loosely upon loose pencils, which latter lie loosely on blocks of carbon. The articulation is excellent in whatever direction the air waves impinge on the pencils, but the tone is very much louder when the air waves impinge on the sides of the pencils and cause them to shake or jolt, and change their points of contact. Such movement is no doubt caused by the vibrations of the air waves, but can a jolting motion be said to be a vibratory motion, or to correspond to a vibratory motion?

It is conceivable that regular vibrations of air waves impinging upon a tympan or diaphragm will cause regular vibrations of the diaphragm or tympan, and those regular vibrations may cause corresponding variations of an electric current; but it certainly is yet to be explained how a jolting or shaking motion producing variations of points of contact of a microphone should produce variations in a current to cause the receiving instrument in the circuit to repeat the articulate words which have produced the shaking or jolting motion.

We now desire to call the attention of the Court to a few extracts from the testimony of our experts:

Professor Young says (p. 393), with reference to the Bell patent No. 174,465: "I understand the method to be a way of transmitting simultaneously, several tele-

graphic signals over a continuous telegraphic circuit by causing vibrations of an iron or steel armature produced by vocal or other sounds in front of an electro-magnet to generate magneto-electric undulations in said continuous telegraphic circuit, and so producing corresponding vibrations at the receiving apparatus."

"23 Q. Do you find any apparatus shown and described in said Bell patent, or referred to in the fifth claim thereof, for transmitting telegraphically vocal or other sounds, other than that which you have described, and which apparatus is illustrated in the drawings of said patent?

"A. I know of no apparatus shown and described in said patent and referred to in said claim other than that which I have already explained in my answer to previous interrogatories.

"24 Q. Do you or do you not find any other method described in said patent, and referred to in said fifth claim, for transmitting vocal or other sounds telegraphically, other than that which you have described in your answer to interrogatory 22?

"A. I do not find any such other method described or set forth.

"25 Q. Referring to said Bell patent No. 174,465, and to extracts therefrom quoted by Prof. Cross in answer to interrogatory 15, of his deposition, do you find therein set forth any practical suggestion which would have enabled any person skilled in the art at the date of said Bell patent to construct an instrument for the transmission of articulate speech?

"A. I do not find any such practical suggestion.

"26 Q. Referring to said Bell patent No. 174,465, do you find any description or statement therein to the effect that articulate speech may be telegraphically transmitted and reproduced by any apparatus therein shown and described?

"A. I do not.

"27 Q. Referring to said fifth claim, patent No. 174,465, state what you understand to be the meaning of the words "vocal or other sounds," as employed in said claim?

"A. I understand them to be sounds suitable for use in multiple telegraphy—that is, musical tones of definite pitch, produced by the voice or other means."

On page 395, after explaining the operation of the Hopkius' transmitter, which belongs to the class of microphone transmitters, and comparing it with the

apparatus shown in the Bell patent, and referred to in the fifth claim, he says (p. 396) :

" I find no similarity, except that both possess draphragms by the vibration of which they produce variations in the strength of the electric current, corresponding more or less perfectly to the aerial vibrations which set the transmitters in operation."

And with reference to the Reis and McDonough transmitters he says (p. 397) :

" I find that the essential elements of all the transmitters are the same. We have in all of them a loose contact of electrodes, in such connection with the diaphragm that the intimacy of their contact will be disturbed by sounds uttered near said diaphragm and will thus produce electric variations in the circuit. In the Reis transmitter the electrodes in loose contact are metallic and have but a small surface. In the McDonough transmitter there are two separate joints of loose contact, and the touching surfaces are narrow streaks of considerable length. In the Hopkins transmitter one surface of contact (and in most forms of the instrument, both) is composed of carbon. In the Reis transmitter (box form) and the McDonough, gravity is relied upon to preserve the contact, while in the Hopkins transmitter the floating power of mercury affords a very delicate means of obtaining the proper adjustment."

On page 401, after being asked in view of the comparison he had made whether the Hopkins transmitter, when properly connected in the electric circuit used for transmission of speech, employs the method or embodies the apparatus described and referred to in the fifth clause of the Bell patent, he replied : " In my opinion it does not."

The same answer would necessarily be given if comparison were made between the Bell patent and the instrument used by the defendant in those cases which are substantially upon the same principle as the microphone.

On page 409 he says :

" I have no doubt that Reis believed that his transmitter acted by making and breaking the circuit in our present sense of the terms.

"I do not consider it certain that the modern microphone does not act in the same manner."

And being asked on the same page:

"68 x-Q. Do you mean to say that in your opinion the microphone operates by making and breaking the circuit, and not by varying the strength of the current which is maintained through the joint during the operation of transmission?" he answered:

"I intended to say that in my opinion it is not yet certain in what precise manner the microphone produces variations in the strength of the current at the receiving end, and that in my opinion the theory that it is done by minute makes and breaks is not demonstrated to be false,"

And on page 410:

"My opinion in the matter does not amount to a scientific conviction. I think it more probable that the separation of the surfaces is not usually sufficient to produce an entire cessation of current, but there are difficulties in the way of this view, and I am by no means sure that the opposite theory is false."

And on page 412 he says:

"I did not intend to commit myself to any theory as to the precise method by which the action of the transmitter produced the undulations in the circuit, but I did intend to say that the method was different from the method of action of any apparatus described and figured in Mr. Bell's specifications."

Speaking of the Hopkins apparatus, on page 413, he says:

"The Hopkins transmitter undoubtedly produces undulations in the current by an action at the loose joint, but I do not know whether that action consists merely in a variation of the resistance without break, or in a succession of short excessively and minute makes and breakes, or in a polarization of the surfaces and the interjection of a variable electro-motive force."

And on the same page:

"The mean strength of a circuit may also be varied by introducing into the circuit a succession of breaks, separated by minute intervals of time—say one ten-thousandths of a second, in which

case, if the line has any considerable self-induction, the pulsation of the further end of the line will become insensible, and practically the same effect will be produced as if the resistance of the line had been simply increased."

And, on page 415, he says:

"I consider the operation of the Hopkins transmitter scientifically identical with that of the Blake transmitter."

And, on page 423, he says, after describing his experiments with Reis instruments, in answer to this question:

"129 Re-x-Q. Do you mean by all that to swear that, in your opinion, the apparatus could break the circuit at each vibration and yet do no mischief, as you call it, to the transmission of speech?

"A. Yes; provided the breaks are sufficiently minute in the extent of space and time.

"130 Re-x-Q. As matter of fact, do you mean to say that you did make that instrument break the current of each vibration, and yet break it for so short a time as to produce no injurious effect upon the transmission of speech?

"A. I mean to say that in my opinion the metallic circuit was interrupted for so small a time, and by so small a space that the resulting diminution of current was just what was necessary to represent at the receiver the motion of the diaphragm which caused the interruption.

"131 Re-x-Q. That is to say, the current was not broken, as you understand it, but only modified or varied, because the metallic circuit did not break far enough to break the electric current; is that what you mean to swear?

"A. Nearly, but not exactly. I am in doubt whether *at the electrodes* the curren' itself may not have ceased for some minute interval of time. My own impression is that at the receiver in such cases the current did not entirely vanish at any time, though I am not sure as to that point, and authorities are not in accordance in respect to it."

And on page 425:

"139 Re-x-Q. In one of the Reis instruments the lever form, a spring is used, pressing the electrode against the diaphragm and against the opposite electrode; did you calculate that the contacts were broken then, when the spring was in action?

"A. No; I only inferred it from the fact that the results obtained

were the same as those obtained with the instrument where gravity alone acted to keep the contact surfaces together."

Professor Brackett says (p. 463):

"I do find that Reis explicitly declares his object to be to transmit articulate speech. I do not find in Professor Bell's specification that he intended or endeavored or succeeded in transmitting articulate speech. I do not intend to declare that we might not apply the word telephone to the apparatus shown in figure 7, nor do I mean to imply that I have any knowledge or belief that an apparatus constructed in accordance with figure 7 had ever, prior to or at the time of the date of said specification, been employed as a telephone in the sense in which the word is now in use.

"The Reis instrument is properly so designated because, as the word which Reis applied signifies, it is capable of and will produce sounds at a distance. And he himself declares that it was his purpose to transmit articulate speech; the word thereby acquired, and still has, a signification which implies such an office. The instrument shown by Prof. Bell is not so called by its inventor, but is shown in connection with and is a part of specification filed with his application for letters patent for a system of multiple telegraphy, in which he distinctly uses the terms signals in accordance with current telegraphic language, and nowhere hints of any intention on his part of employing it as an instrument for transmitting articulate speech."

And on page 467, in answer to cross-question 118, he says:

"I only intend to say, and still do say, that I have not the slightest evidence from the patent itself, nor from any other source whatever, that at the date of Prof. Bell's application, apparatus constructed in accordance with the drawing figure 7 was known to be able to transmit or reproduce articulate speech."

And on page 473, after speaking of the McDonough application of April 10th, 1876, he says:

"The principle involved in his transmitter is essentially that involved in that of Reis. The language employed in said specification is substantially that employed by Reis in describing his invention. Both employ terms which would lead to the inference that they suppose the electric circuit, meaning continous metallic conductors, is abruptly broken and closed during the operation of their transmitters. They nowhere say in set terms as meaning to be

taken in an accurate sense that the *current* is or is not broken or interrupted at each vibration. While he nowhere says, 'that the current is to be varied as nearly as may be to them in simple proportion to the velocity of a particle of air engaged in constituting the sound,' yet this principle is assumed as underlying his whole method of procedure, which is simply an improvement on Reis' method, in which Reis himself expressly says that he has found reason to believe that a correlation such as the question implies exists between the air vibrations and the intensity of the currents controlled by his apparatus."

And on page 477 he says:

"The distinction in modes of telephonic transmission involved in the word microphone had not yet arisen. The method of 'continuous circuit' of the 'magneto method' was not in existence at that date, and of course neither the one method or the other as distinct from the other could have been used in said specification. *He used a method of loose contact, the best known to him, which there is much good reason to believe is one of continuous current when used successfully. The contrary has never been proved.*"

And being asked whether McDonough proposed to make and break the electric circuit as the means for producing the effects proposed by him in his application, Professor Brackett says:

"I will answer the question in the words of the application itself: 'So constructed as to vibrate in accord with the vibrations of articulate sound and so arranged relative to the magnet and circuit breaker that the vibrations of the transmitting membrane or apparatus produced by articulate sound are transmitted by the electrical current to the receiving membrane or apparatus (and so as to cause a like vibration in the receiving membrane or apparatus and it to reproduce the articulate sounds transmitted from and by the transmitting membrane or apparatus.'"

And in answer to the next question he says:

"He unquestionably says circuit breaker. He unquestionably modifies his use of those terms by the expression 'so as to produce,' &c., as quoted above. I will say further, that my belief is that he thought that his apparatus operated by breaking of contact in common with those who had and still have hastily adopted that mode of expression without knowing if with good reason."

And again he says: (pp. 477–8).

"Breaking of the circuit is one thing, discontinuity of the current is another thing. The one may occur, and for aught I know to the contrary, does occur without the other. Indeed, that it does sometimes occur without the other is certain, and was recognized by the early experimenters with these telephones. For instance, so long as a spark appears it is perfectly certain that the current is not broken, while it is equally certain that the continuous conductor provided has been interrupted. Moreover, another illustration: In the electric arc there is discontinuity of conductor, but continuity of current."

And being asked: (p. 478).

"141 x-Q. Is it not perfectly certain that a spark always appears when the circuit is broken, provided the battery is sufficiently strong to make a spark at all, and that the presence of that spark proves that the circuit is broken, itself being the last portion of the electricity that passes?

He replied: "I do not think that this position is tenable or that it accords with the facts that have been brought out by many experimenters.

And on page 483, in answer to a question concerning whether he thought Prof. Henry was ignorant of the Reis machine, and of what had been claimed by it for its inventor and published about it, he replies:

"On the contrary, I think the Court will most distinctly understand that the inference at the beginning of this interrogatory is entirely unwarranted from anything I have said. I am sure that if Prof. Henry were living to-day he would be among the last to maintain, without more light than is now existing, any theory of the manner in which the Reis telephone acts when employed for transmitting articulate speech. He was no doubt familiar with the apparatus and probably with the writings relating thereto. How extensive his knowledge of the literature was I have no means of knowing. I have said *familiar with the apparatus. Its mode of operation is, in my belief, still undetermined.*"

And on page 491 Prof. Brackett says:

"It is still an open question whether that class of instruments known popularly as circuit breakers, of which Reis, McDonough,

Hughes Microphone, Blake Transmitter, &c., are examples, operate by making and breaking the circuit, so as actually, for minute intervals of time, to thereby reduce the current to a minimum, or whether they act through continuous contact but varying pressure to alter the resistance of the line in substantial accordance with the vibrations constitutiug sound, as employed in articulate speech."

And on page 492:

"The theoretical discussions that have from time to time appeared have taken the widest ranges, and have been carried on in apparent candor by gentlemen who cannot be supposed to have any other than purely scientific interest in their decision. For instance, in the text book on general physics, recently appearing in German by Mousson, we have a short summary of the views that have been presented, with the question still left in abeyance. I do not cite the controversies which have taken place evidently in the interest of inventors and companies, either in our country or abroad. I do, however, say that very much of reasonable support for either view can be adduced from undisputed principles of electrical science, as well as from principles of acoustical science."

Professor Channing, on pages 363, &c., describes the Bell patent, and says: (p. 366).

"I find no indication whatsoever in this patent of any purpose to transmit speech or articulate sounds requiring quality as well as pitch. No person acquainted with the existence of the telephone could derive any suggestion of such use to be made by the instrument represented in Fig. 7. The whole character and language of the patent would not convey the impression to any impartial person already cognizant of the existence of the telephone that the transmission of speech was contemplated by Mr. Bell, and had been effected by him at the date of this patent. I also find that the instrument represented in Fig. 7 is so imperfectly described, and is so deficient in essential parts, and so faulty in construction, that no person at the date of this patent could have obtained speech therefrom by virtue of anything contained in the patent, except by merest accident. If so great a discovery as the electric transmission of speech had been made by Mr. Bell at the date of this patent, it would certainly have been unmistakably indicated, and the instrument by which such an effect was produced would have been represented and described in such manner that it could have been constructed by any skilled electric mechanician.

"The fifth claim referred to is for the method of and apparatus for transmitting vocal or other sounds telegraphically, as described in the patent, by causing electrical undulations similar in form to

the vibrations of the air accompanying such vocal or other sounds This claim, as I have already stated, is practically for a method of multiple telegraphy, in the manner described."

And he says, on page 368 :

"The undulatory current, so called, may be very abrupt and have all the characteristics of what is called a pulsatory current.

"Practically, there is no such thing as an instantaneous change of intensity in an electrical current."

After describing the Reis instrument he says (page 371) that all the forms of the Reis telephone operate by varying the current, where not actually broken, by varying the resistance. The variation of the resistance is produced by the loose contact of electrodes, which is more or less perfect according to the relative position, pressure and movements over each other. I refer to the contacts between the platinum strip and platinum points in the box form and in the bored block, and to the contact between the lever and the adjustible spring in the Reis-Legat form. The mode of operation of all the Reis instruments is to produce a correspondence between the vibrations of the membrane and the vibrations of the armature of the electro-magnet or of the knitting needle, by virtue of the changes of distance between the points of contact of the transmitting electrodes; these variations proceeding to the extent of breaking the circuit where the sounds are sufficiently loud. The first mode of operation is particularly used in the transmission of speech, whereas in the transmission of musical sounds the vibrations may be so great as to cause an actual interruption of the current. In the transmission of music the contacts might be entirely broken without injury; in the transmission of speech, the variation of the current without the interruption of the electric current is used.

And on page 115, he says :

"Microphone transmission, which is the system of the Reis and

Blake transmitters and of the Exhibit Defendant's Transmitter now in almost universal use, and not the system of the Bell patent, is effected by varying the resistance to the electric current. This is much more complex than the undulatory system used by Bell in a closed circuit. The current is varied here in a great number of ways. I will instance variation of contact and pressure between two electrodes, which may proceed to the extent of particularly breaking the contact or of entirely breaking the contact. The contact between two electrodes is always a contact of distinct points, which may be treated as separate electrical conductors. Every variation of the contact may break the circuit of a part of these conductors, leaving others intact, and so increase the resistance. This partial breaking of contact also induces secondary currents throughout the surfaces of the electrodes. It also produces thermal effects, varying the resistance. There are also changes in polarization of the opposed surfaces. Where there is a sliding motion of the surfaces, there is a perpetual change of contacts. Variations of pressure also change resistance. This is elaborately stated by Du Moncel, in extracts on pages 63 and 65 of evidence for complainants. There are experiments which tend to show that the electrodes in the microphone transmitter do not touch at all during a large part of the time while transmitting. In this case the discharge is probably a silent one through the film of air intervening between the electrodes. In my own observations of the discharge between electrodes made many years ago, I have noticed a similar silent discharge unattended with any visible spark.

"There is, however, another method by which transmission takes place between electrodes which permits very great variation of resistance. This is when the metallic circuit in which the electrodes are placed is completely broken, and a spark or arc passes between the electrodes. Telephones have been constructed in which no contact whatsoever was permitted between the electrodes of the microphone transmitter, the variation of resistance being probably due entirely to the greater length of spark or arc produced by the vibrations of the diaphragm. The spark or arc may be increased by increasing the number of cells of the batters, or by introducing coils or magnets into the circuit. It will be seen that the variations in resistance taking place between the microphone electrodes are very complex, producing almost an electrical convulsion in the circuit at that point. The electrodes of microphone transmitters may be of metal, carbon or other substances. The Hughes microphones were some of them metal, some of them carbon. In the case of microphone transmitters the electric copy of the sound wave is always very imperfect. The reproduced voice retains only the general features of the original, and the reproduced voice contains almost certainly far fewer of the over tones and other sound vibrations than the original voice.

"I will add that the resistance of conductors, such as the line wire, may crowd and retard a current to such an extent that small interruptions and breaks of the circuit may be partially or wholly obliterated. This is shown in the chemical record of the Bain telegraph, where the dots and dashes of the Bain code are connected by discolorations of the paper, showing that the current is more or less continuous between the signals. The irregularities and breaks, transmissions are equalized in this as well as other ways.

"It will be seen from the above comparison of magneto, transmission and microphone transmission, that there could not well be systems of electric telegraphy or electric telephony, more distinct than that described in the Bell patent No. 174,465, and that now commonly in use and embodied in the Exhibit Defendant's Transmitter.

"The mode of operation of the Exhibit Defendants' Transmitter is substantially different from that of the transmitter if the name can be properly applied to one of the two corresponding instruments shown in figure 7 of the Bell patent No. 174,465."

And on page 298 he says:

"It is the merest assumption that no other method exists for the transmission of articulate sounds than what is called the undulatory current. The vibrations of sounds which enter into articulation are not undulatory. In their ultimate analysis they are to-and-fro vibrations in a straight line."

"They do not resemble the waives of the ocean, nor the undulatory curves which for convenience are made to represent the form of a simple or compound sounds as their relations to time. *We have no evidence whatsoever that any articulate sound cannot be reproduced in the telephone by as many separate electrical impulses as there are separate sound vibrations, the electrical impulses corresponding precisely in number, intensity and combination with those of sound.*"

And on page 300, in speaking of the theory of Helmholz, he says:

"Interpreting thus these graphic records, I have no hesitation in saying that the elements of articulation which are actually influential on the plates, and whichever actually reach the distant receiving end of the line may consist entirely of makes and breaks of different order duration and force."

And on page 301:

"In the case of the loose contact transmitters of the character

of the Exhibit Defendant's Transmitter, where the points of contact or interruptions of contact are innumerable, the probability is that all of the special elements of articulation above referred to, occurring within the limit of each vibration of the diaphragm, are due essentially to the makes and breaks of the current. This is evidenced by the electric spark seen between the electrodes or break pieces of such transmitters during articulation. In the course of a conversation carried on between two parties through instruments of the character of Exhibit Defendant's Transmitter and Defendant's Receiver with the usual connection with switch-board and line wire, I removed the plugs from the switch-board, placing one of them upon my tongue and holding the other in my hand, causing the currents to pass through my body. Under these circumstances, a telephone in the same current being at my ear so that I could carefully observe the character and perfection of the articulation, I felt a rapid succession of small shocks upon the tongue at every prominent word uttered, without any disturbance of articulation. These shocks I consider to be due to the arrest or the reversal of the current, equivalent to a make and break of the character already referred to."

On page 564, after referring to the experiments to reduce these statements to a demonstration, he says:

"While I wish to make the statement with great caution that telephonic articulation has actually been artificially obtained by the simplest make and break apparatus, I yet say that the presumption contained in the question that the undulatory current is the only method by which speech can be electrically transmitted, is overthrown.

"Referring to page 47 of the evidence for complainants in the deposition of Charles R. Cross, I find these words: 'No form of transmitter which operates by making and breaking an electrical circuit can possibly transmit articulate speech or any other sound in its different characteristics of pitch, intensity and quality, for the reason that the constant control, of which I have spoken, is not exercised in such an instrument.' This assumption of an impossibility is contradicted by my preceding analysis of graphic records, and by the experiments and observations which I have just stated.

"It was a celebrated saying of Arago, which has passed into a scientific axiom, that he is a rash man who, outside of pure mathematics, pronounces the word 'impossible.'"

And on page 571 he says, after referring to a letter dated in 1878, in which he had spoken with enthusiasm of Prof. Bell's discovery:

"The clause of my letter which has been read to me was intended to express my admiration for the discovery of the speaking telephone. My opinion now is, in the year 1884, that Philip Reis, the man who discovered that sounds communicated to a diaphragm with suitable electrical connections could affect such changes in an electrical current traversing a line wire that a diaphragm at the other extremity of the line, responding to the vibrations of an electro-magnet, should copy the motions of transmitting diaphragm with sufficient accuracy to transmit intelligible speech, made one of the greatest discoveries of modern science applied to the arts."

And on page 605 he said:

"This is the extent of any personal difference between myself and Professor Bell. It has no influence upon my opinion in the controversy between Mr. Bell and Mr. Gray, or with Mr. Dolbear or Edison, except in so far as it impressed me with Professor Bell's disposition to exaggerate his own claims to invention. I did not become aware until afterwards of the complete anticipation by Reis of the discovery of the speaking tolephone."

Professor Henry Morton, on pages 346, etc., expresses the same opinion as Professor Channing and Professors Brackett and Young as to the meaning of the fifth claim in the Bell patent, and says that he does not find in that patent any description of an apparatus capable of transmitting and reproducing articulate speech, so that conversations can be carried on between separate stations.

And on page 666 he says that there is nothing whatever in the patent which would indicate to a person skilled as an electrician that the instrument would or would not transmit speech, or was designed for the purpose of transmitting speech.

And on page 654, speaking of the distinction between a voltaic current and a magneto-current, he says:

"I mean to say that the differences are sufficient to make it necessary to employ different instruments when we propose to use what is generally understood by electricians as a galvanic current, in place of a magnetic current, as indicated in the Bell patent, in reference to figure 7. In other words, we should have to convert

the transmitter into a microphone, when it would cease to be, as it is now, an instrument of double office, capable of acting both as transmitter and receiver."

And on page 660, speaking of his testimony in the Spencer case, he says:

"I am still of the opinion that any such rupture of contact as I there refer to is inconsistent with the articulate transmission of speech, but various statements which I have heard from others lead me to be at present of the opinion that very minute ruptures of contact are consistent with the transmission of articulate speech, or, still further, that articulate speech may actually be transmitted by *means* of successive minute or brief interruptions."

And on page 662, speaking of the Molecular transmitter, he says:

"I believe that this transmitter makes and breaks this current at numerous points during its operation, though I do not think that it interrupts the entire current or interrupts the current everywhere at any one time. In the Blake transmitter, it is my impression that there is never any rupture or renewal of contact, but there is simply a variation in the minute distance, probably something less than a two-thousandth of an inch, by which the electrodes are separated, such separation being consistent with what we know as mechanical contact. In other words, we say that two bodies are mechanically in contact when they are separated, as a matter of fact, by a distance not greater than a two-thousandth of an inch, and it is my belief that the action of the Blake transmitter depends upon motions of approach and recession, between the electrodes included within this distance."

Second Patent, No. 186,787.

The decree is also erroneous in that it finds that the defendant infringed the 6th, 7th and 8th claims of patent 186,787. The testimony on the subject of these claims is very brief; on the part of the complainant it is that of Prof. Cross and is found on pages 72 to 76, inclusive. The bill of complaint charged the defend-

ants also with having infringed the fifth claim of patent 186,787; on that claim the Court decided in favor of the defendant and dismissed the bill. Prof. Cross's statement of the similarity of the defendants' devices with those described in the 5th, 6th, 7th and 8th claims of the second patent is included in the answer to interrogatory 31. Claim 6 is for the combination with an electric telephone of a sounding box. The patent does not describe the function or purpose of that sounding box, nor, in fact, is it alluded to in the specification; it is shown in the drawing and Prof. Cross says (page 72, third subdivision of answer 30) that one of the chief improvements found in Bell's second patent is the use of a sounding box by which the plate of the instrument is protected from disturbing vibrations.

We remark upon that, first, that it is not an invention. It is the merest mechanical device, which, of course, would occur to any one the moment it was found that there were any such things as disturbing vibrations. It is not a combination. There is no common object or purpose effected by the box combined with any other part of the instrument. As well might he have said that holding his hand or a piece of pasteboard on the top of the diaphragm was a patentable invention, or that it was thereby a combination with an electric telephone. Prof. Cross finds these claims of the second patent only in the defendants' receiver. He does not pretend to find them in the defendants' transmitter. The 7th claim is for the employment of a speaking or hearing tube for conveying sounds to or from the telephone, in combination with an electric telephone, as therein described. The Court will note the long tube attached to the instruments of that patent, shown on page 55; they will note the mere opening to the diaphragm shown in the defendants' receiver, and they will note the brilliancy of imagination of Prof. Cross in describing a hole and a tube as the same thing.

The 8th claim is this: "In a system of electric telephony the combination of a permanent magnet with a plate of iron or steel or other material capable of inductive action, with coils upon the end or ends of such magnet nearest the plate, substantially as set forth." This claim would seem to refer only to the transmitter, as it refers to a material capable of inductive action, and therefore, of course, to be used to produce induced action; the plate in the receiver is not used for inductive action, but, on the contrary, is acted upon by the magnet. So far as it acts inductively on that magnet its results are to be deprecated as tending to throw the same voice back again. The statement of Prof. Cross that he finds that the receivers used by the defendants might be connected and used reciprocally as transmitters and receivers, is wholly unimportant; there is no evidence that the defendants have ever so used them, on the contrary, the evidence is that the receivers are used in connection with the microphone transmitters before described.

Turning now to the witnesses for the defense, we find on page 354 that Prof. Morton testifies that in the Exhibit "Defendants' Receiver," he does not find any sounding box, such as described in claim 6 of patent 186,787, nor does he find any hearing tube for conveying to the ear the sounds produced by the vibration of the plate, and as stated in claim 7; and with reference to the 5th and 8th claims, he says that the magnet described in the Exhibit "Schellen Translation" is identical with the magnet described in the 5th and 8th claims of patent 186,787, As we remember, the witness is asked no question upon the subject of these claims upon cross-examination. On page 632 the witness also testifies that, in his opinion, the Exhibit "Holcomb Telephone" describes practically all the inventions claimed to be found in the 5th, 6th, 7th and 8th claims of patent 186,787.

Turning now to the testimony of Prof. Channing, on page 379, we find that he fully agrees with Prof. Morton, and says that as to the claims 6 and 7, neither the sounding box or hearing tube are found in the defendants' Receiver; and with respect to claims 5 and 8, that the magnet there referred to is identical with that described in the Schellen translation. On page 550 the witness compares the patent 186,787, with reference to the 5th, 6th, 7th and 8th claims, with the Exhibit "Holcomb Telephone," and says that the claims described in the patent 186,787 are found in the Exhibit "Holcomb Telephone." He also states that Exhibit "Specification for Letters Patent No. 32,478," dated June 4, 1861, granted to Holcomb for a magnet, described a magnet which is identical in structure and action with the magnets described in the 5th and 8th claims of patent to Bell 186,787.

Prof. Brackett, on pages 361–2, expresses the same opinion with regard to these claims of the second patent which had been expressed by Professors Morton and Channing. He says that the magnet shown in Exhibit "Schellen Translation" is substantially the same as that shown and referred to in claims 5 and 8 of the second patent, and that he does not find either the sounding box or the speaking tube of the 6th and 7th claims of patent 186,787 in the Exhibit "Defendants' Receiver." The witness also says, on pages 532–533, that claims 5, 6, 7 and 8 of Bell's patent 186,787 are substantially found and described in the Exhibit "Holcomb Telephone;" that the devices are substantially the same.

So far as mere *ipse dixit* is concerned, we certainly have the advantage in the way of numbers. The exhibits, however, are in evidence, and the Court can supplement this testimony of the experts by their own personal examination and inferences. The exhibit "Schellen Translation" is found on pages 747 to 749, inclusive. The figure to the right, page on 748, ex-

hibits the magnet with the coil on the ends. The patent to Holcomb, referred to, is found on page 85, with the drawing on page 184; the coil on the end of the magnet is shown only in figure 1, figure 2 representing only the permanent magnet.

In this connection the attention of the Court is asked to the exhibits showing Dr. Vanderweide's inventions and adaptations, and to the exhibits showing Holcomb's telephone, even assuming it to be, as counsel for the complainant would have us believe, merely a phonetic telegraph, and intended for use only as a receiver.

LAST.

We submit that, in view of the state of the art, Bell's Patent 174,465 must be limited, either—

1. As a patent for a multiple telegraph, or a musical telephone; or,

2. As a patent for the magneto method of transmitting sounds by the energy of air waves and electricity.

That in either case the fifth claim is not infringed by the method or apparatus used by the defendants.

That neither the fifth, sixth, seventh or eighth claims of the patent No. 186,787 are infringed by the receiver used by the defendants.

That the judgment of the Court below should be reversed, and the cause remanded to the Court below, with instructions to dismiss the bill, with costs.

GROSVENOR LOWREY,
WHEELER H. PECKHAM,
H. D. DONNELLY.

APPENDIX NO. 1.

Die Elektricität im Dienste der Menschheit, von Dr. Alfred Ritter von Urbanitzky. A. Hartleben, Wien, Pest, Leipzig. 1886.

Vol. II., p. 882. Fig. 639.

THE HISTORICAL DEVELOPMENT OF TELEPHONY.

Since it is the province of this present work to treat only of the application of electricity and magnetism, it is not necessary to discuss carefully those experiments whose object is to render audible by non-electric means the spoken word at a greater distance than the human voice can reach. Hence we shall only mention briefly here the methods relating thereto, which are partly in use at the present time.

Already in 1667 R. Hooke announced that a stretched cord could transmit to a considerable distance both tones and spoken words. At present the string telephone is a widely known child's toy. It consists of two metal or card-board boxes whose bottoms are connected with each other by a stretched string. Talking into the box at one end of the string is heard at the other end of the string, if the ear is held to the box at that end. It is not known to whom to ascribe the invention of this string telephone. For a long time it is said to have been used in Spain as a means of communication between lovers. On the other hand, the invention of it is ascribed to Adolph L. Weinhold. Morland, as is well known, invented in 1670 the speaking-tube, much used at the present time. In 1819 Wheatstone produced his magic lyre. In this a spruce rod

connected with a sounding-board served to transmit sound.

The fundamental experiment for the electric telephone is the galvanic tones discovered in 1837 by Page, and critically studied since by Wertheim, De La Rue and others. The galvanic tones arise by the magnetization and demagnetization at very short intervals of an iron rod. This experiment also forms the foundation of the first telephone by Philipp Reis. The priority of the German inventor has been much questioned, still we believe that in all the existing, very extensive mass of material there is nothing that can form a reasonable basis for earnest doubt. A claim for priority has been sought lately for Ch. Bourseul, on account of an article which Dr. Luckenbein published in "L'Illustration," of the 26th Aug., 1854. We give the places in the article referring to this subject.

"I have asked myself, for example, whether it may not be possible to transmit speech by electrical means; in a word, whether we might not be able to hear in Paris what was spoken in Vienna. The thing is practicable, and in the following manner. Tones are, as is known, formed by vibrations and are brought to the ear by vibrations of the air (sound-waves). But the intensity of the latter vibrations decreases very rapidly with the increase of the distance, so that in the speaking-tube we soon reach a limit beyond which we cannot pass. Let us suppose that we speak against a metal plate, which is so movable and flexible as to reproduce all the vibrations produced by the voice and that this plate be so connected with an electric current that it should alternately make and break the current according to the air vibrations by which it is struck—then it would be also possible to so arrange a second similarly constructed metal plate, that it should simultaneously complete exactly the same vibrations." It is then expressly said if the plate *were* so made that it *would* be possible * * * and this,

in our opinion, is nothing more than the *wish* to invent the telephone.

That Bourseul did not fulfill this wish, is shown by the following passages: "Without doubt the intensity of the tone-vibrations produced at the place where the metal-plate vibrates by the voice, would be changeable, whereas at the point where the metal-plate vibrates by means of electricity it remains constant. But it is well known that this in no way changes the pitch. So it is plain, that the tones will be reproduced in the same pitch of the scale. *The present condition of acoustical science does not permit us to assert, a priori,* that the *same conditions hold true for the spoken syllables of human speech.* It is not yet known how those sounds are produced * * * However, it may be, the syllables can be exactly reproduced by sound-waves: *reproduce exactly these sound-waves and you will also have exactly reproduced the spoken syllables.*" From these passages it seems to us perfectly clear that Bourseul did not know how the plate must be formed, how it must be electrically connected with a second plate, and how the sound-waves should be exactly reproduced in order to reproduce the syllables, let alone having made a suitable instrument. In the notice quoted, in conclusion it is also stated: "I have commenced experiments, which are difficult and demand time and patience, but the success attained permits us to foresee a favorable result." The result then was not yet *reached,* and nowhere are to be found the means and manner designated by which to reach the sought-for result, and the less so, since we consider the ruling and generally accepted theory of the time, that a plate must be regulated to different high tones by more or lesser tension.

The priority of Reis has also been attacked by asserting that Reis in fact had produced an instrument, by which tones could be transmitted at great distances, but which was not able to reproduce human speech. Yet this view cannot be maintained, if one will give an im-

partial consideration to the existing documents and publications. Reis is, as Grahwinkle very well stated it, not the inventor of *a* telephone, but of *the* telephone.

Philipp Reis was born on the 7th Jan., 1834, at Gelnhausen. His father, master-baker and farmer Reis, soon recognized the prominent mental qualities of his son, and sent him therefore to the Garnier Educational Institute, in Friedrichsdorf, near Homburg. He left here at fourteen years of age, and then received farther education in the Hassel Institute, at Frankfort-on-the-Main. Although his teachers, advised the young Reis to go to the Polytechnical School, at Carlsruhe, he was compelled, deferring to the influence of his uncle, to devote himself to a mercantile career. He entered, at sixteen years of age, as an apprentice, a color and dyeing establishment, but studied eagerly in his leisure hours chemistry, physics, mathematics, and attended lectures on Natural Science at the Business School.

When he had finished his apprenticeship, he renounced his mercantile career and entered the school of Dr. Poppe, at Frankfort, in order to devote himself to the profession of teaching. In 1855 he was obliged to go to Cassel to fulfill his military duty, and afterwards, in 1858, received a position as teacher in the Garnier Institute. Already, early in the year 1852, Reis was busy with experiments in reference to the transmission of sound. As he had no means at his disposal, he had to help himself with very primitive apparatus. The first apparatus consisted, according to reports of Dr. Messel, of a beer-cask, in whose bunghole a small cone was placed. This was

closed at its narrower end by an animal membrane, upon which was fastened by means of a bit of sealing wax a strip of platinum or wire. This strip opened and closed the current according to the vibrations of the membrane. As simple in form was the receiver, *i. e.*, that apparatus which should receive the current impulses and reproduce the tone. It consisted of a knitting needle surrounded by a coil of wire and fastened upon a violin; the violin served as a sounding-box. Later he gave to the sender—that is, to the instrument which sends to the receiver the current impulses, and which receiving the sound waves transforms them into the electric impulses—the form of the human ear, as represented in Fig. 637.

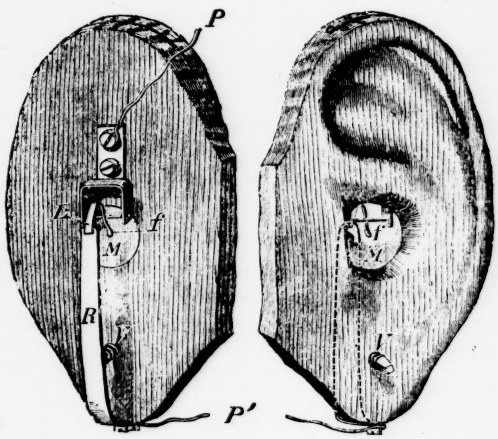

Fig. 637.

In this model, roughly carved out of wood, the platinum wire *f* was fastened at one end by sealing-wax upon the membrane M, and, therefore, in a manner represented the "hammer" of the human ear. The platinum contract L, fastened at its free end to the spring R, was placed opposite this. The screw V

allowed the regulating of this spring. The wires P P′ were the connections of the instrument with the battery. When then the membrane M was set in vibration by sound-waves, the circuit P, *f*, L, R, and P′ must be correspondingly opened and closed, depending upon whether *f* and L were separated or touched.

The apparatus, in course of time, underwent many changes which would carry us us too far to describe. Moreover, the experiments with the apparatus first constructed gave no satisfactory results. This is the reason for passing herefrom immediately to the description of the final apparatus.* (Here follows cut and description of the square-box transmitter and needle receiver copied from Pisko's book.) The author, however, explains the action as follows: When one speaks or sings into the mouth-piece S, the air enclosed in the box begins to vibrate and the membrane *m* must take part in the vibrations. The vibrations of the air, as is easily seen, cause changes of the contact at S, and thereby variations of current in the circuit. These call forth changes of the magnetic condition of the iron core, which hence falls into vibration and so reproduces the sound-waves which caused the vibration of the membrane.

For the first time, and still in very primitive form, Reis showed his apparatus to the Physical Society at Frankfort-on-the-Main, in 1861, and to the same Society, on July 4th, 1863, in the form represented in Fig. 638. This time transmitter and receiver were separated 300 feet.

Dr. Boettger showed the apparatus in 1863 to the Assembly of Natural Scientists at Stettin. The ap-

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* This latter is pictured and very fully described in Dr. F. J. Pisko's "Die neueren Apparate der Akustik," Wien, 1865. This book contains also exact data of the results of experiment which the author of the work cited had obtained. Fig. 638 is taken from it.

paratus was made by Albert in Frankfort, and later by Hauck in Vienna, and a circular composed by Reis was added with each instrument.

The circular reads,* "Telephones. Each apparatus consists, as can be seen from Fig. 638, of two parts, the real telephone A, and the reproducing apparatus C. These two parts are set up at such a distance apart that the singing or toning of one musical instrument can be heard from one station to another in no other manner than through the apparatus. Both parts are connected with each other and with the battery B, like ordinary telegraphs. This battery must be sufficient to produce at station A the attraction of the armature of the electro-magnet (V), attached to the side (3 to 4 Bunsen cells are sufficient for a distance of several hundred feet).

The galvanic current passes then from R to the binding post at *n*; from here by the copper strip to the small platinum plate upon the middle of the membrane, thence through the pin at S of the triangular piece to the screw *b*, in the hollow of which is placed a drop of mercury. Thence the current passes through the small telegraphic apparatus *e v*, then to the key station C, and through the coil back to B.

If now sufficiently strong tones are produced before the opening serving to receive the sound, through the vibrations of the tones, the membrane and the little angular-shaped hammer resting upon it are set in vibration; the circuit will be opened and closed once for every full vibration, and thereby at station C the same number of vibrations will be produced in the iron rod of the coil as are heard at the other end as tone or tone combination (accord). The tones at C are much increased by tightly pressing the cover upon the coil. *Besides the human voice* (according to my experience),

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* F. J. Pisko, "Die neueren Apparate der Akustik," p. 241.

allowed the regulating of this spring. The wires P P′ were the connections of the instrument with the battery. When then the membrane M was set in vibration by sound-waves, the circuit P, *f*, L, R, and P′ must be correspondingly opened and closed, depending upon whether *f* and L were separated or touched.

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* F. J. Pisko, "Die neueren Apparate der Akustik," p. 241.

the tones of a good organ pipe von F—$\overline{\overline{c}}$ and those of the piano can be reproduced.

For the latter purpose A is placed upon the sounding-board of the piano. (A skillful experimenter was able to recognize 10 trichords out of 13). As regards the attached telegraph apparatus, it is plain that it is unnecessary to the reproduction of tones; but it is a very convenient attachment for convenient experimenting. This is worked somewhat in the following simple manner: After the apparatus is set up complete, by opening and closing the circuit one can test the continuity of the circuit, by hearing at A the stroke of the armature, and at C a very audible click of the coil. The circular coil then gives forth a sort of alphabet, by means of which correspondence can be carried on.

There has been much eager discussion as to whether the Reis telephone was able to transmit only tones or also words. From the documents at hand, we consider it beyond all doubt that words were also transmitted, and as a proof of this, we would add to the material which Thompson in his Biography of Reis* has most carefully collected, a letter in autographic form, which was written by Reis to F. J. Pisko (Fig. 639) on the 18th of October, 1863.

We call attention to the following passage in this letter: "The instrument gives whole melodies, the scale between C and c very well, and I assure you that if you will visit me here, I will show you that one is able to understand also words."

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* We refer here to Thompson: Philipp Reis, Inventor of the Telephone, "La Lumiere Electrique," Vols. VI., VII., X., XII. Elektrotechnische Zeitschrift, Vol. IV., Uppenborn. Zeitschrift fur angewandte Elektricität, Vol. IV.; Zeitschrift fur Elektrotechnik II., etc., etc., at foot of page 2.

*Reis' letter to F. J. Pisko, author of "Die neuren Apparate der Akustik," Wien, 1865.**

MOST HONORED SIR:

In answer to your distinguished favor of the 16th inst., allow me first to express to you my thanks for your friendly interest in my invention and for kindly sending me your interesting article.

Your wish regarding the sending of articles and drawings I can fulfill only very imperfectly, as my time does not permit me to comply with the demands in this regard that are made upon me from all sides.

I therefore refer you to the only article published by me (Bericht des physikal. Vereins zu Frankfurt a—M, 1866-1861), which you can surely obtain there. Furthermore, the apparatus of the latest construction will be described in Pouillet—Mueller's Lehrbuch der Physik, last edition (in press). Moreover, I add description, as is done with each instrument, and would say to you that Mr. Hauck, mechanician in your place, has ordered an instrument and can certainly give you information.

Regarding the explanation upon page 15 of your programme, I must say that the conclusions drawn, although rightly based upon former suppositions, are totally false (simply because the suppositions are false). The apparatus produces whole melodies, the scale between C and *c* very well, and I assure that, if you will visit me here, I will convince you that one is able to understand also words.

How is it that the tympanum of our ear can reproduce all tones with their quality (Klangfarbe), Accords, etc.? ? ? !

It would certainly be best if you would convince yourself of the simplicity and correctness of the facts.

With especial regard,

Yours obediently,

(Signed) PH. REIS.

Friedrichsdorf 18 | 10 | 63.

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* Mr. Government-Councillor Director F. J. Pisko had the kindness to put this interesting letter at my disposal. Regarding the contents of this letter, it must be here remarked that at this time it was thought that a membrane must be regulated for different pitches by a difference of tension, and that it could not produce all tones at once. Hence it could not, in fact, be expected, that without a regulating device on a membrane, it would be able to take up and reproduce all the tones of a sound. Practice has here corrected theory.

Reis recognized also the importance of his invention, which at that time was called "toy," as is clear from a remark that he made to Garnier: "That he had shown the world the way to a great invention, but he must now leave to others the development of the same." In the year 1862 Poggendorff refused a description of the apparatus sent in for the "Annalen," because he held the transmission of the sounds of speech by means of electricity as a "myth." In 1864, after the telephone had already been shown many times in different assemblies, Poggendorff sought for an article.

But to this request the poor, undeceived schoolteacher answered: "I thank you very much, Professor; it is too late. Now, *I* will not send it. My apparatus will become known even without a description in the "Annalen."

Far in advance of his age, misunderstood and little encouraged, a disease of the lungs completed what sickness and discouragement had begun; in 1873 his illness brought the pitiable inventor to his sick-bed, after he had already in 1871 lost his voice; he seemed, however, to recover, and again took up his duties as teacher.

He died January 14th, 1874, and rests in the churchyard at Friedrichsdorf, where a monument was erected to him by the Physical Society of Frankfort-on-the-Main.

APPENDIX NO. 2.

This appendix consists of a paper prepared by the witness Paddock for another purpose, but which is printed entire and without alteration.

Mechanical Defects in Reis Instruments.

The Reis instruments are known to us, in the order of their invention, as the Bored Block, the Reis-Legat and the Cubical Box Transmitters; the Knitting-Needle, and the Reis-Legat Receivers.

The Bored Block Transmitter, in the original instrument possessed by me, consists of a block of wood bored with a conical hole, whose larger diameter is 2½ inches, and whose smaller diameter is ⅜ of an inch. Over this smaller opening is stretched a piece of animal membrane, evidently that of an intestine of some animal. It is held in place by simply being pasted to the wood. The electrodes or contact-pieces are both of platinum, one a small disc glued to the centre of the membrane, and the other a short platinum wire soldered at right angles to a thin strip of brass, which forms with it the so-called "hammer-piece" of the transmitter.

Leaving out of question the mode of operation of this instrument, whether by a broken or unbroken current, there are many difficulties of a mechanical nature which stand in the way of its perfect operation. In the first place, a diaphragm of animal membrane responds to the vibrations of the human voice only when stretched and under considerable tension, and then at its best with an approximate accuracy. Moreover, the tension is continually changing from atmospheric changes, and especially from the moisture of the breath

while speaking, so that a part only of the vibrations of the voice are taken up by this membrane, and these vibrations are, further on, impaired by passing to the platinum disc; for, unless that disc is secured in intimate and close contact at every point with the membrane, the vibrations are imperfectly transmitted; and in practice it never is so secured. The wax or glue which fastens the two is warm when attached, and necessarily contracts in cooling, and subsequently, under the jarring of the voice, is detached at many points from both membrane and disc. So rapid is this action that the disc often becomes entirely detached, and has to be reset. *Attention was called to this difficulty by Pisko in 1865.* It follows from the above conditions that many vibrations are lost and others are impaired at the very outset.

Another source of difficulty is found in the "brass strip" which forms the "hammer-piece" of the transmitter. It is, of course, a necessary requisite that this hammer-piece should follow accurately the vibrations of the membrane or diaphragm, whether the electric current is reduced to zero by the parting of the contacts at each vibration or not; but, for mechanical reasons, this is not the case. The brass strip is held at one end by a "binding-post;" the opposite end being left free. When this hammer-piece is "pushed back" by the advancing diaphragm the voice is the moving-force, and the hammer-piece moves in accordance with it and against its own elasticity and tension; but when following the diaphragms in the opposite phase of the vibration it moves in obedience to its elasticity and tension, which are here the moving force. The lack of suitable means to regulate this elasticity and tension render it difficult to operate the instrument successfully. However, with patience and care it has been so operated, without any alteration or additional devices whatever.

In order to demonstrate to the eye or ear at the

transmitter that " breaks " are produced in its mode of operation, it is necessary to speak to it in a violent and explosive manner, and under these conditions it will transmit many words and sentences. It is probable in this case that the hammer-piece does not move with sufficient rapidity and freedom, and that the " breaks " produced are *not* at " each and every vibration."

Perhaps my meaning here will be made clearer by a graphical illustration, taken from the tracings made by a delicate pointer, then attached to a diaphragm actuated by the human voice, thus, in a certain degree, accurately representing the vibrations in question. Taking this one, representing the vibrations produced by the vowel *o* in " mood." (A very rude copy, but it answers the purpose.)

(The curves are omitted.)

Figs. 1, 2, 3, 4, 5, 6, &c., may represent single vibrations so modified in character as to produce the sound of this letter. Now, if we consider the diaphragm as passing through the details of this vibration, the hammer-piece which follows it, breaks contact at the *highest point* of the vibration, and resumes it again as quickly as its elasticity will permit. In such a case it might be said that it breaks contact at each and every principal vibration.

In the case of the vibrations produced by such a word as " incomprehensibility."

(Curve omitted.)

The facility with which the hammer-piece can follow the diaphragm in and out through these sharp and sudden alterations of motion will determine where the " breaks " will occur. When it is possible for the hammer-piece to move with the desired mobility, articulate speech is transmitted clearly and distinctly, and breaks

are undoubtedly present, as shown by photographic records of the movement of the diaphragm and hammer-piece. Photographic records of the vibrations of the diaphragm at the receiver will further demonstrate the *parting of the electric current* at such breaks.

On the original Reis transmitter the sound of the "breaking," when the instrument is operating best, approaches to that of a musical note, not far from the fundamental tone of the human voice. Experiments might be devised in which the number of such breaks should be compared with the number of vibrations constituting such fundamental tone as bearing upon Reis' statement that the current is broken at each vibration.

In the Reis-Legat transmitter the mechanical difficulties, as far as regards the diaphragm, are the same; but in this instrument the "lever" or S-shaped arm, which takes the place of the "hammer-piece" in the first or bored block form, presents both advantages and disadvantages over that form. Its advantages are found in an adjusting screw and light spring, which furnish a means of regulating the electrodes, and its disadvantages are found in the "lever" being able to follow the diaphragm perfectly by reason of its *non*-attachment to that diaphragm and the liability of the lever to move on its fulcrum during vibration. These difficulties are easily removed by a few mechanical changes, and the instrument then becomes a decided improvement on the bored block form, and a step leading to the final form—the Cubical Box Transmitter. In this last transmitter the force of gravity or weight of the "hammer-piece" plays the important part in the operation of the instrument. The "hammer-piece" is lifted against this weight and returns in obedience to it, and if the movement of this hammer-piece under gravity had been left unhampered by additional details in its structure, it would have operated far better than any of the previous forms, since "gravity" has been

found to be superior to all springs and mechanical devices for this purpose, and the force chiefly relied upon in modern commercial battery transmitters. This hammer-piece, as is well known, is formed of an angular piece of metal, supported at three points, and each in a different manner. At the vertex of the angle, and directly over the centre of the diaphragm, it is supported by the "platinum foot," which forms one electrode. At one extremity of the angle it is supported by a screw, which passes through a circular hole in the metal-strip, and at the other extremity by a peg or foot which dips down into a cup of mercury.

The electric current enters by means of the mercury-cup to the angle and passes out by its platinum-foot to a platinum-disc on the centre of the diaphragm. The other arm of the angle conveys none of the "current." When in operation, the point of support directly over the centre of the diaphragm (viz., the platinum foot), is lifted and allowed to fall back again with each vibration; at the same time, however, displacing slightly the other two points of support. This displacement is inappreciable with a single vibration, but accumulates under the rapidly vibrating motion, and very soon the hammer-piece is impeded in its movements, either by the friction of the peg on the sides of the mercury-cup or by the binding of the circular opening on the screw which passes through it. When this occurs the hammer-piece fails to respond accurately to the vibrations of the diaphragms, and speech is necessarily imperfectly transmitted.

Another difficulty is that when in good working order this same hammer-piece is easily thrown out of its nicely-balanced condition by any extraneous noises, such as the closing of a door or by walking across the room, or even by speaking with too explosive an utterance; and when so displaced there is no certain or definite way of restoring the adjustment. It can only be accomplished by numerous trials, such as slightly lifting

are undoubtedly present, as shown by photographic records of the movement of the diaphragm and hammer-piece. Photographic records of the vibrations of the diaphragm at the receiver will further demonstrate the *parting of the electric current* at such breaks.

On the original Reis transmitter the sound of the "breaking," when the instrument is operating best, approaches to that of a musical note, not far from the fundamental tone of the human voice. Experiments might be devised in which the number of such breaks should be compared with the number of vibrations constituting such fundamental tone as bearing upon Reis' statement that the current is broken at each vibration.

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the hammer-piece from its supports, moving it a hair's breadth one side or the other, as I have more fully pointed out in my testimony in the Overland cases (Deft.'s Proofs, Vol. I., p. 667).

The weight of the hammer-piece also must be neither too great nor too small, and the amount required will vary with each and every instrument, and can only be determined by practical tests, adapting the one to the other (Reis reserved this work for himself). I have found 16 to 20 grains to be the best weights for instruments used by me. The hammer-piece of the Reis instrument at Washington, and made by Koenig, weighs about 21 grains.

The cubical box of this transmitter is an impediment rather than a help to its proper operation, for it is a well-recognized fact in acoustics that the resonance of such a box seriously impairs the articulation of the human voice. The reflected sounds mingling with the direct vibrations partially obliterate the latter or modify their character to a considerable degree. It is such impaired and disturbed vibrations which actuate the diaphragm of this instrument when it is spoken into through the mouth-piece. Much clearer and more distinct articulation is obtained by speaking down into the diaphragm from above, without the intervention of the box, and much better still by removing the lid of the box and speaking under it.

Turning now to the receivers; the knitting-needle and Reis-Legat are both good receivers and correctly reproduce whatever vibrations are transmitted by the electric current. Their principal defect lies in the *faintness of* the sounds which they emit, which renders many vibrations *out of the reach of human hearing*, unless reinforced in some way, which the instrument does not provide.

It has been ascertained by numerous experiments—

FIRST. That articulate speech is perfectly reproduced in a telephone receiver *without a diaphragm.*

SECOND. That the *core* of the helix reproduces the sounds by itself.

THIRD. That the *coil* of wire or helix without the iron core will do the same.

Without entering into the question of the nature of the changes which take place in the receiver, it is sufficient to say that in the case of the sounds emitted by the coil and its iron core, they are undoubtedly produced by molecular contractions and expansions in the coil and core itself, *under the influence of a changing electrical equilibrium*, and that they correspond to, and are exact *reproductions of the cause of that change, whatever that cause may be*, be it musical sounds or articulate speech. The failure of the ear to detect them all arises from the lack of proper means to reinforce and convey them to the ear with sufficient intensity to affect the auditory mechanism. The Reis knitting needle receiver aims at this by placing the coil and its core on a resonant box, which reinforces the sound somewhat, but at a disadvantage, for had the needle been placed vertically instead of horizontally, and with its extremities resting against the box and its cover, the longitudinal vibrations of the core would have been communicated directly to the resonant box, and the sound would have been reinforced effectively. This was done by Prof. Eaton, of Brooklyn, *in 1875, with marked* success.

Another point deserves mention, which is the peculiar "buzzing sound" so often spoken of as characteristic of this receiver. This sound is dependent on the use of the transmitter. It is entirely absent when the transmitter is spoken to in modulating tones. The receiver is capable of producing smooth and even tones like modern receivers; but they are very faint when thus produced, and the means of reinforcing them are not sufficient to render all of them distinctly audible in the ear.

The Reis-Legat receiver has the advantage of adding to the sounds produced by the core and coil, and much

more effective vibrations of an iron armature placed in front of the core and acting under its influence. This armature carries a vertical sounding-board, which is intended to render its vibrations audible to the ear. In point of theoretical construction this instrument is identical with the modern magneto-receiver, and operates upon precisely the same principle. The mechanical changes necessary to convert it into a modern telephone are simply the alteration of the shape of the armature and its manner of support. It will operate as it is, both as a receiver and a transmitter, the same as is the case with the Bell magneto-receiver.

It might also be remarked in this connection that all battery transmitters, such as the Blake, Edison, &c., will also act as receivers, dispensing entirely with magneto coils in this case, and the same is true of the Reis transmitters. In point of fact, any disturbance produced at a *loose contact* in an electric circuit will be faithfully reproduced at another loose contact.

This I have verified by numerous experiments.

(Signed) JOHN R. PADDOCK.

APPENDIX NO. 3.

History of Undulatory Currents in Telegraphy.

Mr. Bell was not the first to use undulatory currents in a system of telegraphy. Such currents were well known in the telegraphic art and were used therein long prior to his alleged invention thereof.

In the year 1833, Messrs. Gauss & Weber, of Göttingen, Germany, invented a telegraphic apparatus in which undulatory currents were employed. It consisted of a single magnetic bar, or needle, inclosed in a coil of wire, and the currents were produced by a magneto-electric inductor. The inductor consisted of a hollow column or standard enclosing three straight, permanent bar magnets, each weighing about twenty-five pounds and having their poles placed in the same direction. Mounted upon the hollow cylindrical standard was a wooden bobbin provided with handles, having about 7,000 convolutions of insulated copper wire wound upon it. The bobbin so mounted upon the top of the column surrounded the upper portion of the bar magnets, so that on its being lifted by the handles a current of electricity would be induced in the coil in one direction and on lowering the bobbin again a current would traverse the coil in the opposite direction. The wires of the coil of the inductor suitably connected to a commutator, by means of which they communicated with the line wires. The receiving instrument consisted essentially of a large coil, or multiplier, of insulated copper wire, the ends of which were suitably attached to the line wires. A permanent steel magnet about eighteen inches in length was suspended within the coil or multiplier of the receiving instrument by a number of silk fibers, from the ceiling of the room in

which it was placed. The magnet was provided with a rod or spindle to which was attached a mirror in which could be observed, through a telescope placed at a distance, the reflected image of a divided horizontal scale. By raising and lowering the bobbin of the inductor at the transmitting station the magnetic needle or bar suspended within the multiplier at the receiving station was deflected to the right or left as the case might be. An alphabet was arranged consisting of a combination of right and left deflections with a maximum of four elementary signals in each letter. A slight deflection of the magnet was greatly multiplied by the action of the mirror and the telescope. The receiving apparatus so used contained the essential elements of the deflecting galvanometer now extensively employed in cable telegraphy. Gauss & Weber's line was erected between the Physical Cabinet and the Observatory of Göttingen, and was used for the purpose of transmitting magneto-electric currents between the transmitting and receiving stations. The currents thus generated and used in their apparatus were in all respects substantially like those employed in the apparatus described and claimed in the Bell patents in suit.

In the Dolbear case it was proven by Professor Dolbear that the method of Gauss and Weber was substantially the same as that used in the apparatus shown in Fig. 5 of Bell's patent of March 7, 1876.

Dolbear Circuit Record, 335, 416, 416, 418, 419, 420.

In the "Telegraphic Journal and Electric Review," London, November 15th, 1872, volume 1, page 4, Sir Charles Wheatstone describes an apparatus wherein magneto-electricity is employed for various purposes. Many means had been devised for the purpose of registering at a distance the periodical motions of a machine or the number of changes in the positions of a turnstile or a door. Those of the earliest dates were

merely mechanical, and their use was limited by the short distance to which the motions could be communicated. Mechanical registers were of necessity cumberous, and must remain exposed to view and dust, or be covered at great expense.

So far back as 1840 Sir C. Wheatstone invented an instrument for this purpose, founded on the principles of his electro-magnetic step-by-step telegraph when voltaic electricity was applied thereto; but batteries involved troublesome chemical operations, and if not constantly attended to their inactivity caused the failure of the entire system. Voltaic batteries are subject to many accidents through which a temporary irregularity in the registration might ensue. They might be situated in so cold a place that in winter the exciting liquid would be frozen or the vases cracked, or they might be exposed to the heat radiated from hot-air or water pipes, or other source of warmth, and the liquid evaporated to crystallization, the crystals forming a non-conducting coat upon the electrodes of the pile; but given success with the battery the rapidly succeeding contacts rendered constant inspection necessary. The spark that appeared on breaking contact was nothing less than a minute particle of the metal of the contact-point in a state of incandescence, and it followed that where the current passed and was interrupted many times a minute, the contact-points were speedily worn away. This difficulty was subsequently overcome by employing magneto-electric currents in a suitable apparatus for the generation of such currents in an electric circuit never broken. By reference to the publication it will be seen that the essential elements of the apparatus for generating the currents are a small compound permanent magnet having helices of fine wire with soft iron cores, one of which is attached to each of the poles of the permanent magnet. The magnet is also provided with an armature of soft iron. A spring to which the armature is attached

presses it against the soft iron cores of the bobbins, thereby maintaining the strength of the magnet when the apparatus is not in use. By means of suitable mechanism (eccentric and pitman shown in Fig. 3) the armature is caused to approach and recede from the poles of the magnet, thus inducing alternate currents in the coils thereof. These currents are transmitted by a leading wire to an indicator where they act by means of an electro-magnet upon a step-by-step motion which in turn operates the pointers of the dials precisely similar to the motion imparted to the needle of the receiving instrument of the A-B-C-Telegraph.

In this device an unbroken current of electricity is used, modified and rendered undulatory in form by the approach and recession of the armature to and from the poles of the electro-magnet. The current is produced without a battery and is magneto-electric in character like that employed in the apparatus described in the Bell patents.

Another method and apparatus, in which undulatory currents are employed similar to those used in the Bell patents numbers 174,465 and 186,787, are described and set forth in the "Varley patent" which will be found between pages 546 and 566, Part Second of the Dowd record (O., pp. 3642–3658). The patent was sealed June 7th, 1870, and is dated April 8th, 1870. It declares the nature of the invention to be for "improvements in electric telegraphs." The invention has for its object the increase of the transmitting power of telegraphic circuits by enabling more than one operator to signal independent messages at the same time upon one or the same wire to and from independent stations.

On page 554 of the Dowd record (O., p. 3647), the inventor says:

"By my invention I superpose upon the currents used for working the ordinary telegraphs rapid undulations or waves which do not practically alter the mechanical or chemical power of the ordinary signal currents, and by new apparatus hereinafter described,

these undulations are made to produce distinct and independent *audible* or other signals so long as these undulations are produced, whether ordinary signal currents be flowing or not."

The drawings of the patent exhibit an ordinary telegraph line consisting of Morse instruments, sending key for Morse signals, and a battery connected to the key and with the earth. Condensers are connected to the line wire and key, and are by means of such key put into communication with the cymaphens or wave signal receiving instruments.

One form of apparatus for generating and transmitting undulations or waves, shown in the drawings and described in the patent, consists of an induction coil, in the primary circuit of which are interposed a battery suitably connected with an electro-magnet between whose poles a tuning fork is placed, and so arranged that when at rest the battery current flowing through the electro-magnet causes the latter to attract the tuning fork and break the circuit; the magnetism then ceases and the tuning fork springs back and renews the circuit. In this way the tuning fork vibrates so long as the local battery is in action. The induction coil is provided with two primary coils wound in opposite directions and so connected to the contact springs, between which one prong of the tuning fork vibrates, that currents alternately pass in the two primary coils, and at each alternation the polarity of the coil is reversed. The induction coil is also provided with a secondary wire, in which currents are induced by the changes in the polarity of the core of the coil. One end of the secondary wire of the induction coil is connected with the earth, and when a wave signal is to be sent, connection is made with the condenser-receiver and line wire by a Morse key, and thus there is produced in the condenser rapid charges and discharges, thereby causing loud musical notes and sounds. When the finger key is in its normal position, the condenser is only in communication with the wave signalling instrument.

With the transmitting apparatus described in the Varley patent, a regular succession of electric waves of nearly sinusoidal form alternately positive and negative are superposed upon the steady current of the line produced by the batteries in the line circuit. These waves or undulations are transmitted either to condenser-receivers or to a cymaphen, causing the same to produce audible signals and musical tones.

The wave signalling instrument called a cymaphen, consists essentially of an iron frame containing a sounding board, over bridges, at the ends of which a hard drawn iron or steel wire is stretched and tuned so as to sound the same note as the transmitting instrument. This wire passes through a hollow helix of insulated copper wire. The coil of wire is attached to the frame supporting the sounding board, but does not touch it. Two horse-shoe magnets are placed on each side of the wire. The currents magnetize the wire inside of the helix and thus cause it to be attracted and repelled from one magnet to the other. The wire is properly tuned so as to vibrate synchronously with the apparatus causing alternations in the current at the transmitting station.

The patentee says: "By attaching a stethoscope to the sounding board for the hearer to rest his ear against very feeble sounds are rendered sufficiently audible. The sounding board may be replaced by a strained diaphragm or drum head on which one of the bridges over which the wire is strained is supported. This arrangement gives a better sound with very feeble currents, but with moderate currents the sounding board appears to have the advantage. Two sets of wave signals may be transmitted and received simultaneously through the same wire and independently of the current signals, if a sufficient difference be made in the periods of the two sets of waves. Thus if waves of 200 vibrations in the second, and 850 or 900 vibrations in the second be simultaneously transmitted and

received by two separate cymaphens, the one adjusted to the slow and the other to the rapid vibrations, they may be separately read as the vibrations which affect the one are inoperative upon the other. The patentee says that various forms of receiving apparatus may be used, and among others he shows and describes a condenser-receiver.

On page 563 of the Dowd Record, **O.**, p. 3656, the patentee says:

"There are several methods of producing the electric waves in the line in addition to that already described. A tongue similar to those used in harmoniums is made to vibrate by *air* between contact points, and so to connect the condenser alternately with the battery and the ground and so produce the alternations, or it may be made to connect the condenser alternately to the positive or negative pole of a battery whose opposite poles are connected to the earth. A magneto-machine rapidly rotating will do the above duty equally as well if its speed of rotation be controlled by a good governor."

On page 564 of the Dowd Record, **O.**, p. 3657, the patentee says:

"I would remark that in electric-telegraphs the use of sound signals is not clained by me, and is not new; for example, in working step-by-step instruments in which a pointer should indicate the desired letter on a dial, it has been common when the instrument is out of order, or fails to indicate correctly, to give sound signals; by its means such sound signals are read according to the Morse alphabet, a short sound such as the escapement of the receiving instrument makes when moving a few steps only representing a dot, and a long sound such as the escapement makes when moving over many steps representing a dash."

"Having thus described the nature of my invention, and the manner of performing the same, I would have it understood that I claim the construction of electric-telegraphs in such manner that current signals and wave signals may be simultaneously transmitted through the same line wire, and may be rendered sensible at the receiving station by separate instruments, the one sensitive to currents of appreciable duration, and the other to electric waves or vibrations."

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receiving station a strained wire, a tongue, or such like instrument adjusted to vibrate in *unison* (correspondence) with the electric waves, and being magnetized by them, oscillating to and from the pole or poles of a magnet in its vicinity."

* * * * * * *

"I also claim in the construction of electric-telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a condenser consisting of thin sheets (tin-foil) capable of being agitated by such waves."

At pages 400 and 401 of the defendant's record in the Molecular case (**O.**, pp. 797, 798), Professor Young testified that there is no substantial difference between the so-called undulatory current employed in the apparatus shown in the Bell patent No.174,465 and the undulations or waves employed in the Varley apparatus.

In the Dowd case, Vol. I., page 205; **O.**, p. 2990, Mr. E. S. Renwick testified that vibratory or undulatory currents of electricity had been employed for telegraphic purposes previous to the date of the Bell patent, citing among others the Varley patent (See Prof. Morton, M. R., pp. 354, 355; **O.**, pp. 751, 752; and Prof. Brackett, M. R., p. 362; **O.**, p. 759).

In the Dolbear case, pages 256 and 257, Prof. Cross says:

"In my first affidavit in this case I referred to the fact that previous to the date of the Bell patent electrical variations in the secondary circuit of an induction coil were utilized to produce sound by causing *vibratory* movements in *plates*. In this statement the defendants considered that I was mistaken. I had in mind three particular pieces of apparatus—first, the receiver of Dr. Wright, described by him in the transactions of the Royal Scotch Society of Arts, 1860-1864, Vol. VI., pp. 185-187; second, a somewhat different condenser-receiver of Dr. Wright, described in Ferguson on Electricity in 1867, page 38; third, the condenser described by Varley in his English patent No. 1044 of April 8, 1870. In the Varley apparatus one plate of the condenser was connected with one terminal of the secondary helix of an induction coil, in which the primary circuit was made and broken by a tuning fork or other suitable arrangement. The purpose of the Varley was to produce in the receiver the pitch of the transmitted sound in a system of harmonic multiple telegraphy * * * I still believe that the operation of

those condensers of Wright and Varley was due to the attraction of the plates of the condenser for each other as the potential of the one connected with the induction coil was raised or lowered and thus the nature of the operation was essentially the same as that employed by Mr. Dolbear in his receiver."

At page 264 of the Dolbear record Prof. Cross says:

"The voltaic condenser constructed as in Mr. Varley's patent already referred to is also capable of reproducing speech, though less readily."

"I find that small instruments, constructed as described in Ferguson's Electricity, enclosed in a suitable case, will also reproduce articulate speech with tolerable distinctness so as to be understood."

In Cross' first affidavit, page 84, Dolbear case, he says:

"That the attractive power of one plate upon another varied with the electrical condition of the first, was well known before the date of Mr. Bell's said first patent; it was also well known before the date of said patent that by this means the electrical variations in the secondary circuit of an induction coil could be made to cause such vibratory motion in a plate as to thereby produce a sound whose pitch corresponded to the rate of the electrical variations. And this device for converting electrical variations into sound waves was well known as an equivalent and substitute for the motion given to the vibrating armature by means of the varying attraction of an electro-magnet through whose coils the same varying current should be passed."

In this connection it will be noted that the current employed in the Varley apparatus is precisely similar to that of Mr. Bell. In Mr. Bell's lecture, delivered before the Society of Telegraph Engineers, in London, October 31st, 1877, he described the operation of Fig. 5, in his first patent, as follows:

"Fig. 48 shows the form of apparatus that I was then employing for producing undulatory currents of electricity for the purposes of multiple-telegraphy. A steel reed A was clamped firmly by one extremity to the uncovered leg of an electro-magnet E, and the free end of the reed projected above the covered leg. When the reed A was vibrated in any mechanical way the battery current was thrown into waves and electrical undulations traversed the current

* * * throwing into vibration the corresponding reed A′ at the other end of the circuit."

In Mr. Bell's English patent, page 93, Dowd Record, Part Second, **O**., p. 3556 the patentee says:

"When the permanent magnet is caused to vibrate in front of the pole of an electro-magnet which is placed in circuit with a voltaic battery, the undulatory current induced by the vibration of the permanent magnet is superposed upon the voltaic current. When the induced impulse is of similar polarity to the voltaic current it serves to strengthen the intensity of the latter, but when it is of opposite polarity it tends to neutralize the voltaic current. In such an arrangement the resultant effect of the vibration of the permanent magnet is to *throw the battery current into waves*, as in line 3, Figure 6, by alternately increasing and diminishing the intensity of the current."

In Part Second of the Dowd Record, between pages 501 and 546, **O** pp. 3592–3637, will be found British Leters Patent number 6345, dated 1840, granted to Wheatstone and Cooke for improvements in giving signals and sounding alarms between distant places by means of electric currents. At page 503, **O**., p. 3594 the patentee says:

"An apparatus capable of giving signals and sounding alarms is represented in Sheet 1 of the drawings hereunto annexed. One such apparatus is to be situated at one of the distant places, and another like apparatus at the other of the distant places, between which commuication, of the nature of telegraphic intelligence, is to be carried on by giving signals and sounding alarms by means of electric currents transmitted through two long metallic wires extending from one of the distant places to the other, and forming a metallic circuit, in the manner fully explained in our said former specification; that is to say: The said two long conducting wires or telegraphic wires forming a continuity of metal, and being kept insulated one from the other (although laid close side by side), if the end of one of the two wires is brought in contact with one pole of a voltaic battery and the end of the other wire with the contrary pole of the same battery, the two distant ends of both the wires being conjoined with metallic contact, then the two wires will form what is called a metallic circuit, through the whole length of which an electric current will be transmitted in consequence of a continual transmission of electric action, which as soon as such circuit is formed, begins

to proceed from one pole of the battery along or through all the length of one wire, and then back again through all the length of the other wire, with a great velocity of transmission, in order to return to the other pole of the same battery, the electric current thereby performing a circuit from the battery and back again thereto; and providing the battery is kept in working order, the said electric current, or transmission of electric action in a circuit, will continue without interruption or cessation so long as the metallic circuit is maintained; that is, so long as the aforesaid contacts of the ends of the two wires with the two poles of the battery (and so long as the continuity of metal throughout the whole length of the two wires and at their distant ends) is continued."

The apparatus described in the patent is the well-known Wheatstone Dial Telegraph, and the principle of its action is that of sending from the transmitting station a series of alternating currents through the line which, passing around the cores of an electro-magnet, moved an armature and controlled the motion of a step-by-step escapement similar to that of a clock. On page 530 of the Dowd Record (**O.**, p. 3621), the patentee says :

"By the further improvement now about to be described, a magneto-electric machine is substituted for a voltaic battery for the purpose above mentioned, and the same may, under some circumstances, be a more convenient agent, as requiring comparatively little or no care and attention."

Reference is then made to Figures 18, 19 and 20, sheet 9, of the patent, as showing a magneto-electric machine of ordinary construction. The machine and its action are then described. The specification then says :

"The difference between the use of electro-magnetism as hereinbefore described, and that of magneto-electricity as now being described, consists, therefore, of a momentary duration of the latter as contrasted with the continuous action of the former. The practical effect of this difference is, that whereas by electro-magnetism a distinct and available signal is obtained by each action, and one by each reaction of the escapement-wheel; on the other hand, by magneto-electricity an available signal is obtained by the reaction alone, because the action of the occasional magnetism upon the

escapement wheel is merely momentary, and does not admit of the signal being prolonged for a sufficient time to be intelligible, consequently the revolving dial hereinbefore described as giving 24 signals under the influence of electro-magnetism would, if submitted to the influence of magneto-electricity, according to our present improvement, give only 12 signals."

The apparatus illustrated in Figures 18, 19 and 20 of the drawings consists of a magneto-machine or inductor connected in a closed metallic circuit with a receiving apparatus at a distant station, capable of giving signals or sounding alarms.

On page 545 of the Dowd Record (**O.**, p. 3636) the patentee says :

"Part K is the improvement hereinbefore described, and represented in Figures 18, 19 and 20, Sheet IV., for employing the attractive force of occasional or temporary magnetism, which will be excited in soft iron by transmission of electric currents through metallic circuits for the purpose, by action of such attractive force on suitable mechanism, of sounding alarms, when such electric currents are produced by magneto-electric apparatus instead of by voltaic batteries."

The action of the apparatus above referred to is substantially that described in the specification of the Bell patent No. 174,465, wherein it is stated that

"When a cylinder upon which are arranged bar magnets is made to rotate in front of an electro magnet an undulatory current of electricity is induced in the coils of the electro-magnet."

At page 571, Part Second of the Dowd Record (**O.**, p. 3668), will be found letters patent granted to Thomas A. Edison, August 12th, 1873, No. 141,777, for an "improvement in telegraphic instruments." The specification sets forth that relay-magnets are employed to a large extent in various telegraphic operations, and that it is found that the adjustment of the springs which draw back the armature, and the burning of the contact-points by the spark are sources of constant annoyance. The patentee then says :

"My present invention is made for preventing the points burning out, and for avoiding adjustment of the retractile armature-springs.

"I make use of metallic contact-points, within a liquid, such as glycerine or water, so that the motion of one contact point nearer to or farther from the other raises and lowers the electric tension in the telegraph line, and operates a distant magnet without forming a spark or breaking the circuit."

The drawings show and the specification describes a local circuit consisting of a finger-key connected with a battery and a relay-magnet. The relay-magnet is provided with an armature affixed to a lever moved by a spring in one direction and by the attraction of the relay-magnet in the opposite direction.

A cup or vessel containing water, glycerine or other suitable liquid is interposed in the line circuit. The bottom of the cup is provided with a screw projecting upward in the liquid, and is connected to the main circuit-wire, leading to one pole of the line battery. The other pole of the line battery is connected to earth. The armature lever of the relay-magnet is provided with a movable point, or screw, the lower portion of which always projects and dips into the liquid contained in the circuit-cup. The upper portion of the screw has metallic connection with the circuit wire leading to the receiving-magnet. In the Edison apparatus the main, or line circuit is never broken, and a continuous voltaic current is always flowing therein.

When the local circuit, that is to say, the circuit of the relay-magnet, is broken at the finger-key, or otherwise, the lever-electrode immersed in the circuit-cup, moves away from the cup-electrode, lessening the tension in the line-circuit, by the resistance of the intervening liquid, and thereby weakening the power of the receiving magnet, so that its spring or weight will draw its armature away from the pole of the magnet.

It will be noted that by alternately making and breaking the local battery circuit, the armature of the relay-magnet will be alternately attracted to and re-

leased from the pole of that magnet, thereby causing the screw affixed to the end of the armature-lever to be immersed more or less deeply in the liquid of the circuit-cup. The action thus produced is substantially like that described by Mr. Bell in the specification of his first patent, wherein he says (**O.**, p. 43):

"For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current. Hence, vibration of the connecting wire in the mercury or other liquid included in the circuit, occasions undulations in the current."

In the specification of the Edison patent the inventor says:

"I am aware that contact-points within a liquid, such as oil or glycerine, have been employed in the circuit-breaker of an electric-engine. In my improvement the circuit is not broken, but the relay-magnet or *sounder* is operated by rise and fall of tension, and the contact-points are adjustable instead of varying the armature-spring of a magnet."

The Edison patent shows a telegraphic apparatus wherein a closed circuit is employed, the electromotive force of which is constant, but the resistance of the circuit is alternately varied through the instrumentality of a local circuit, consisting of a battery, a key, and relay-magnet.

In the Dowd Record, Part One, page 334 (**O.**, p. 3119), Mr. Frank L. Pope testified that the Gray patents for improvements in electric telegraphs for transmitting musical tones numbered 166,095, 166,096, dated July 27, 1875, and patents numbered 2646 and 173,460 describe a method of inducing electrical undulations in a closed circuit, by the vibration of a reed or diaphragm moved by the impact of air waves accompanying the production of sound. The patents referred to are found in Part Second, Dowd Record, 566–571 (**O.**, pp. 3659–3668), 577–582 (**O.**, pp. 3676–3683), 615–

620 (**O.**, pp. 3721–3726), 650–651 (**O.**, pp. 3756–7). Testifying in relation to those patents Mr. Pope said:

"The two patents of Mr. Elisha Gray, for 'Improvements in Electric Telegraphs for Transmitting Musical Tones,' dated July 27, 1875, and numbered respectively 166,095 and 166,096, describe a method of inducing electric vibrations in a closed circuit, and reproducing them upon a common or universal receiver. The transmitting apparatus described in these two patents is substantially the same, and is that represented by defendant's Exhibit, Gray's Two-Tone Transmitter." (The instrument referred to is shown and described in the Johnson patent, Part Second, Dowd Record, page 566, **O.**, p. 3659). "It consists of two automatic circuit breakers, each of which opens and closes a separate branch of a primary circuit, at a definite rate of vibration, the rate of each circuit breaker depending upon its construction or adjustment, and being different from that of the other. By saying that each circuit breaker is placed in a separate branch of a primary circuit, I mean that the current from the primary battery, after leaving one pole of the battery, is divided between two branching conductors which lead respectively to the circuit breakers, after passing through which they again unite in a single large post, situated between the two circuit breakers in the exhibit, and thence pass to the primary wire of an electro-magnetic induction coil. In each of these branches is a finger key, which when closed puts in action the automatic circuit breaker in that branch. The secondary wire of the induction coil forms a portion of a closed circuit extending from the transmitting to the receiving station, at which latter place it passes through a common receiver which in the patent 166,095 consists of an electromagnet with a hollow cylinder of metal placed upon its poles, and in patent 166,096 consists of a hollow metallic cylinder connected with the ground, upon which cylinder the operator rubs his finger, holding at the same time in his hand an electrode connected with the line wire, so that the circuit is completed through a portion of his body. Either of these two forms of receivers is capable of reproducing all the different characteristics of sound. In patent 166,095 it is stated that 'mechanical circuit breakers might be substituted for the automatic vibrating electrotome, hereinbefore described,' and in patent 166,096 it is also stated that the interruptions in the primary circuit, which cause the induced secondary currents or impulses, may be produced by a mechanical circuit breaker, having the requisite rapidity of motion, such as a revolving wheel or revolving brush; or they may be produced by providing the vibrating reed or reeds of an organ with contact points, so that, as the reed vibrates it will transmit impulses corresponding in number per second to the number of vibrations per second of the notes

sounded by the organ pipe. In Elisha Gray's patent, number 173,460, for 'Improvement in Automatic Circuit Breakers for Electro-Harmonic Telegraphs,' dated February 15, 1876, the last-mentioned form of circuit breakers is described in detail. The specification says: 'My invention relates to electro-harmonic telegraphs of the class secured to me by Letters Patent of the United States, numbered respectively 176,095 (which I suppose to be a misprint for 166,095) and 166,096, granted July 27, 1875. Its object is to produce a simple and effective circuit breaker, vibrating automatically with sufficient rapidity to produce a musical tone of a given pitch, the electrical impulses thus generated being transmitted through an electric circuit, and reproduced at the other end of the line, as set forth in my patents above mentioned; to which end my improvement consists in combining with an organ, or other wind pipe, a diaphragm vibrated by sounding said pipe, and an electric circuit connected with said diaphragm so as to be opened and closed by its vibrations.'

The drawings show and the specification describes an organ pipe of the usual and well-known construction, but having an opening in its side, over which a membranous diaphragm is stretched. The diaphragm carries a contact point, which plays against another fixed contact point mounted upon a metallic bar over the opening. The operation of the apparatus is described in the specification in the following language: 'When the column of air in the pipe is vibrated by sounding the pipe, the diaphragm will vibrate correspondingly with the musical tone thus produced, and open and close the circuit accordingly, thus transmitting the vibrations to the receiving instrument for utilization, as mentioned in my patents before referred to. Obviously, the vibrations of several pipes, giving notes of different pitch, may be simultaneously transmitted through a single wire by suitable mechanism.'

I find, therefore, that Mr. Gray's patents, Nos. 166,095, 166,096 and 173,460, when taken in connection with each other, describe and show a method of inducing electrical undulations in a closed circuit by the vibrations of a reed or diaphragm caused to vibrate by the impact of air waves accompanying the production of sound, and reproducing them upon a common or universal receiver."

On page 336 of the same record (**O.**, p. 3121), Mr. Pope further testified:

"The extract from patent number 166,096, which I quoted in my last answer, in my opinion gives a sufficient description of the manner of operating the apparatus by means of the vibrating reed or reeds of an organ, to enable any person skilled in the art at the date of the patent to construct, arrange and operate the apparatus as contemplated therein."

On page 374 of the same record (**O.**, p. 3159), referring to Mr. Gray's closed circuit patent No. 186,340, January 16, 1877, taken in connection with his reed transmitter patent 165,728, dated July 20, 1875, Mr. Pope says:

"It fulfills these conditions for the reason that each one of the reed transmitters controls a certain proportion of the total electromotive force, and this wholly irrespective of the action of any other one of the reeds. Now, as the resistance of the main circuit remains practically constant, it is evident that the strength of current in that circuit is always exactly in proportion to the algebraic sum of the amplitudes of all the waves belonging to the different series co-existing at any given moment. As the apparatus is arranged, this proportion is inverse, but this is a matter of detail which does not affect the general principle. I referred to the other patent mentioned for the reason that it shows in detail the construction and mode of operation of a reed transmitter adapted to and designed to be used with the arrangement of circuits described and shown in the closed circuit patent."

See Bell's London lecture, page 66, Prescott, Speaking Telephone (**O.**, p. 2723), and Dowd Report, Part I., page 376 (**O.**, p. 3161) and 220 (**O.**, 3005).

In a paper read before the annual meeting of the American Electrical Society, December 12, 1877, by Mr. F. L. Pope, the subject of electro-harmonic telegraphy was elaborately discussed. Mr. Pope's paper is found in "The Speaking Telephone," by Prescott, pages 235–260. On page 252 Mr. Pope says:

"The next important step in the progress of invention was obviously the discovery of some means whereby the proper amplitude of each vibration or succession of vibrations, either simple or compound, could be directly reproduced by means of the electric current, and when this was done the general problem of harmonic-telegraphy may be said to have been solved. This having been accomplished, it was not difficult to foresee that two important practicable applications might be expected to follow, namely, multiplex transmission and vocal transmission. I believe that this discovery of the true method of transmitting composite vibrations was first publicly announced in the journal of this society (Journal of American Electrical Society, Vol. I., p. 13), in a paper contributed by Mr. Elisha Gray, it having been made by him in December, 1874.

It consists in causing the effective strength of the electric current by which the transmission is effected to rise and fall with the varying amplitude of the vibrations or waves which are produced. Nothing could be more simple and beautiful in a theoretical point of view; but the practical exemplification of the method, as is usual in such cases, presented considerable difficulty."

On page 254 he described in general terms the nature of Mr. Gray's improvement, by means of which he was enabled to transmit an indefinite number of series of vibrations without destroying their individuality. After doing so he sums up the whole matter in these words:

"The reproduction of articulate vocal sounds at a distance depends upon precisely the same fundamental principle as multiple harmonic-transmission—namely, the transmission of *composite* vibrations."

The apparatus of Mr. Gray referred to is shown and described in Gray's patents Nos. 1,874, May 4, 1876 (Great Britain), and 186,340, of January 16, 1877 (United States).

The patents last named have previously been referred to, and it has been shown that the apparatus, when in operation, employed an undulatory current.

On page 320, Part I., Dowd Record, **O.**, p. 3105, Mr. Pope, testifying in regard to his report made to the Western Union Telegraph Company in October or November, 1877, says:

"It was substantially to the effect that I regarded the fundamental principle of the speaking telephone to be the method of transmitting what are technically termed *composite* tones—that is to say, the simultaneous transmission of two or any greater number of tones over a single wire without destroying their individuality, and of simultaneously reproducing these tones at the receiving station—a method which necessarily involved the use of a closed or uninterrupted circuit in the main line, and of a common or universal receiver, capable of responding with equal facility to tones of every description, whether simple or compound. I stated that, in my opinion, based upon all the facts which I had been able to get hold of, this method was first invented by Elisha Gray, and therefore I

regarded it as most important to obtain control of his invention and patents."

On May 9, 1879, Pope testified (Dowd Record, p. 321, **O.**, p. 3106), that he then remained of the same opinion expressed in his report as to what constituted the fundamental principle of the speaking telephone, and as to where it was to be found described and embodied.

On pages 321–322 of Dowd Record, **O.**, pp. 3106–3107, he defines what he meant by the terms "common or universal receiver."

On pages 322, 328, 329, 330 (**O.**, pp. 3107, 3113, 3114, 3115), Mr. Pope refers to the apparatus which he saw exhibited in New York in 1875, upon which his report was based, and to Mr. Gray's patents, in which said apparatus is shown and described.

The apparatus referred to by Mr. Pope, and the experiments therewith, are fully set forth in the depositions of William M. Goodridge, Elisha Gray and others, Part I., Dowd Record, **O.**, Vol. IV.

Undulatory currents, as defined by Mr. Bell in the specification of his first patent, were used by Siemens and Halske in what is known as "the magneto-induction key." The instrument is shown and described on pages 697, 698, 699, Part II., Dowd Record, **O.**, pp. 3815–16–17.

Instead of the Morse key, induction coil and local battery Siemens and Halske used an instrument in the form of a key, in which a coil of wire wound on a soft iron armature was oscillated between the poles of a permanent magnet and developed alternate, positive and negative currents for working a polarized relay. The induction key consisted of two rows of permanent bar magnets, the upper one with their north ends and the lower ones with their south ends in contact with a heavy, soft iron plate. Between the poles of this system of magnets the armature was placed and oscillated in an angle of a few degrees by means of a handle.

Longitudinal grooves were cut on opposite sides of it in which a coil of fine insulated wire was wound. The coil of the armature was suitably connected to the line wire and with the earth. When the handle of the armature was pressed down the polarity of the armature was reversed and a positive magneto-electric current was induced in the coil of the armature, which flowed into the line wire and deflected the tongue of a polarized relay or receiving instrument at the receiving station, and thus closed a local circuit so long as the key was held down. The currents induced by the vibration of the armature were magneto-electric currents and were undulatory in character.

On pages 699-702, Part II., Dowd Record, **O.**, pp. 3817-3820, will be found a description of certain improvements made by Professor Wheatstone in the apparatus patented by himself and Mr. Cooke in 1840, to which reference has already been made.

In this apparatus, like that previously described, the currents used to work it were magneto-electric and were evolved from permanent magnets. A succession of magnetic currents were generated and transmitted in the sending apparatus by causing a pair of electro-magnetic coils to revolve rapidly above the poles of a compound permanent steel magnet. A succession of magneto-currents were thus induced and sent, and as long as the electro-magnetic coils were caused to revolve, the indicators or pointers of the receiving dial were moved on step by step. During this operation the current was unbroken and the currents induced were undulatory in character.

In complainant's record Drawbaugh case, Mr Bell was asked:

"331 x-Q. How long prior to June 2d, 1875, had you known that if a permanent magnet be vibrated in front of the pole or poles of an electro-magnet in a closed circuit, and sufficiently near to bring the electro-magnet within the field of force of the permanent mag-

net, electric currents would thereby be caused to traverse the circuit in alternately opposite directions, even though there were no battery included in the circuit?

"A. I do not know. I had all the knowledge necessary to know this, if I had thought about the matters, when I first took up the study of electricity; certainly previously to 1870, the date of my coming to this continent. I am not conscious of having thought of applying this to vibrations coming with the frequency of an audible sound, for the purposes of my inventions, until the summer of 1874.

"332 x-Q. How long prior to June 2d, 1875, had you known that if an electro-magnet be included in a closed circuit with a battery, and a plate or armature of inductive material be vibrated in front of the pole of the electro-magnet and within its field of force, electrical undulations would thereby be set up in or transmitted through the circuit?

"A. I am not conscious of having thought of this until the summer of 1874.

"333 x-Q. Do you claim to be the first discoverer of the effects stated in my last two questions, or either of them, or were they known to other electricians prior to your investigations?

"A. I think that the state of knowledge at the time I made my discoveries was such that the effects stated could have been deduced from the premises supposed. I believe myself to have been the first person to have made the deductions and to have applied them to the case of the sonorous vibration of a permanent magnet, or plate, or armature of inductive material in front of the pole or poles of an electro-magnet placed in a closed circuit as stated."

In answer to x-Ques. 334, Mr. Bell says:

"My inventions and researches had reference entirely to vibrations that would produce the sensation of sound, and I do not believe that the effects stated in your two questions were actually known to electricians before I deduced them, although, as I have stated, the state of knowledge at the time was such that they might have been deduced. In regard to vibrations in the simple sense of a to-and-fro movement, without reference to a movement of such character as to produce the sensation of sound, I said in my patent of March 7, 1876: 'It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet, a current of electricity is induced in the coils of the latter, and that when it is made to recede a current of opposite polarity to the first appears upon the wire.' In regard to the conditions stated in x-Ques. 332, I do not know exactly how much was actually known to electricians at the date of my discoveries in reference to simple to-and-fro motions, but it is obvious that whatever effects might have been positively known regarding the to-and-fro

motion of permanent magnets in front of electro-magnets would also have been presumed to follow in the case of plates, or armatures of inductive material moved to and fro in front of the pole of an electro-magnet excited by a battery current."

In answer to x-Ques. 335, Mr. Bell said:

"I deduced from the known laws of magneto-electricity that the variations in the electric current induced by that to-and-fro movement of a magnet or of inductive material under the conditions stated in your two questions would correspond to the motions themselves, so that if the changes in the current were graphically shown they would be represented by a curve substantially similar to the curve that would represent the motion of the inducing body. In answer to the first part of the question, there was nothing in the state of knowledge to have prevented any one from arriving at this conclusion in the case of to-and-fro movements at the time that I did, but I do not believe that any one had arrived at this result.

"An article published in 'The Wonders of Electricity,' entitled 'The Acoustic Telegraph,' led me to substitute metallic plates for tuning forks in my telegraphic experiments."

Exhibit Bell Caveat, Part II., Dowd Record, 711; O., p. 3829.

The article referred to will be found in the Dolbear Circuit Record, pp. 611–613.

In Mr. Pope's paper, heretofore alluded to, Prescott's Speaking Telephone, 249, he says:

"The idea of synchronizing the movements of the two instruments at widely separated points for telegraphic purposes, by making use of the principles of ischronous vibration, was employed in telegraphy at a very early period. Thus Ronalds in 1861 and Vail in 1837 employed ischronous pendulums to control their machinery, while at a later date the printing telegraph of Hughes and the automatic telegraph of Casselli and others have embodied most ingenious applications of the same principle."

APPENDIX NO. 4.

Upon the facts already shown touching Bell's actua knowledge of the writings and instruments of Reis, the following comparison of their words is made without remark:

REIS.	BELL.
"How, indeed, could a single instrument produce the combined effect of all the organs occupied in human speech?" (Reis & Bourseul Pub., p. 12; **O.**, p. 1864).	"I remember when I was quite a child that my father spoke to me of some automaton speaking machine that he had seen, and aroused so much interest in me that I determined to attempt the construction of such an apparatus. I invented a speaking machine and constructed it as a boy, and was able to make it articulate one or two simple words" (Mol. R., p. 1586).
"But I was soon forced to desist because the very first experiment convinced me of the impossibility of its solution" (Reis & Bourseul Pub., p. 12; **O.**, p. 1864).	"I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time" (Mol. R., p. 1682).
"because I did not feel myself equal to the difficulties in the way" (*Ibid.*, p. 12; **O.**, p. 1864).	"I added that I felt that I had not the electrical knowledge necessary to overcome the difficulties" (Mol. R., p. 1682).
"finally I got the notion of putting the question in another way—'How is our ear affected by the totality of vibrations produced by the organs of speech all simultaneously active?' Or, more generally, 'How are we	"At the very time also when this conception occurred to me, I was obtaining tracings of the vibrations of the bones of a human ear, * * *" (Mol. R., 1597).
	"I have a recollection of ask-

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affected by the vibrations of several simultaneously-sounding bodies?'" (*Ibid.*, p. 12; **O.,** p. 1864),

"With the above principles (*i. e.*, construction and action of the human ear) as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the tones of various instruments, and even to a certain extent the human voice" (*Ibid.*, p. 15; **O.,** p. 1870).

"What our auditory nerve perceives is, then, simply the effect of a force coming within the range of consciousness, and this force can be represented both as to duration and magnitude graphically by a curve" (*Ibid.*, p. 13; **O.,** p. 1865).

"The pitch of the tone produced in this way depends upon the number of vibrations in a given time. * * *" (*Ibid.*, p. 18; **O.,** p. 1873),

"The greater the condensation of the sound-conducting medium, at any given moment, the greater is the amplitude of vibration of the membrane * * *" (*Ibid.*, p. 13; **O.,** p. 1865).

* * * each tone depends not merely upon the number of

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ing Dr. Blake's opinion on this point, and the impression that I got from his remarks was that it could, if the membrane were made concave, like that in the human ear, * * * corresponding to the point of attachment of the malleus and tympanic membrane of the ear" (Mol. R., p. 1599).

"I cannot remember these discussions with any detail, but simply remember holding this human ear in my hand, * * * as an illustration of some theory I was discussing concerning the reproduction of speech by electrical means" (Mol. R., p. 1598),

"Electrical undulations, induced by a body capable of inductive action, can be *represented graphically* without error by the same sinusoidal *curve* which expresses the vibration of the inducing body itself and the effect of its vibration upon the air; for, as above stated, the act of oscillation in the electrical current corresponds to the *rate of vibration* of the inducing body—that is, to *the pitch of the sound produced*" (Specification of U. S. Patent, No. 174,465; **O.,** pp. 39-46).

"The intensity of the current varies with the amplitude of the vibration—that is, with the loudness of the sound" (*Ibid.*).

"and the polarity of the current corresponds to the direc-

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the vibrations of the medium, but also upon its condensation and rarefaction (*Ibid.*, p. 35; **O.,** p. 1892).

"If, for example, in the case of three tones, we draw the curve of condensation of each separately, then by a summation of the ordinates of corresponding abscissas, we can determine new ordinates and develop a new curve, which might be called the combination curve. This represents exactly what our ear perceives of the three simultaneous tones" (*Ibid.*, p. 14; **O.,** p. 1866).

" * * * the electro-magnet * * * is correspondingly demagnetized and magnetized, and the armature of the magnet is set into vibrations like those of the membrane of the transmitting apparatus" (*Ibid.*, p. 34. **O.,** p. 1891).

"The transmitter * * * consists of a conical tube * * * closed by a collodion membrane * * * by speaking into it * * * a movement of the membrane closing the smaller opening of the tube is produced * * *" (*Ibid.*, pp. 32, 33, 34; **O.,** pp. 1888, 1889, 1890).

"The apparatus * * * offers the possibility of producing these vibrations in every manner desired; and by the use of

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tion of the vibrating body—that is, to the condensations and rarefactions of air produced by the vibration" (*Ibid.*).

"The combined effect of **A** and B, when induced simultaneously on the same circuit, is expressed by the curve AB, Fig. 4, which is the algebraical sum of the sinusoidal curves **A** and **B**. This curve AB also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously * * *" (*Ibid.*).

"The electrical movement, like the aerial motion, can be represented by a sinusoidal curve, or by the resultant of several sinusoidal curves" (*Ibid.*).

" * * * the current traversing the coils of the electro-magnet **E**, occasions an increase and diminution in its intensity, and the armature A is thrown into vibrations * * * and thus imparts to the air at *n* a *fac simile* copy of the motion of the air that acted upon the membrane *n*" (Specification of British Patent No. 4765, Dec. 9th, 1876; **O.,** p. 3563).

"A cone is used to converge sound vibrations upon the membrane."

"When a musical note is made in the neighborhood of the membrane, it is set in vibration * * *" (*Ibid.*, p. 3563).

"* * * and thus electrical undulations are created upon the circuit. * * * The undulatory current passing through the

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galvanic electricity, it is possible to evoke, at any distance, vibrations like those which have been so produced, and in this way to reproduce at any place the tones which have been generated at another place" (*Ibid.*, p. 32; **O.**, p. 1888).

"As soon, therefore, as it shall be possible * * * to set up vibrations whose curves are like those of any given tone or combination of tones, we shall receive the same impression as that tone or combination of tones would have produced upon us (*Ibid.*, p. 55).

"Any sound will be reproduced, if strong enough to set the membrane in motion" (*Ibid.*, p. 45; **O.**, p. 1902).

"* * * the armature of the magnet is set into vibrations

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electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. * * * These undulations are similar in form to the air undulations caused by the sound."

"that is, they are represented graphically by similar curves. * * *"

"A similar sound to that uttered into A is then heard to proceed from L" (Specification of U. S. Patent No. 174,565; **O.** p. 45).

"* * * there are many other uses to which these instruments may be put, such as * * * the telegraphic transmission of noises or sounds of any kind" (*Ibid.*, p. 44–45).

"I would have it understood that what I claim is:—' * * *

"FIFTH. In a system of electric telegraph or telephony consisting of transmitting and receiving instruments * * * united upon an electric circuit, I claim the production in the armature of each receiving instrument of any given motion by subjecting said armature to an attraction varying in intensity, however such variation may be produced in the magnet; and hence I claim the production of any given sound or sounds from the armature of the receiving instruments, by subjecting said armature to an attraction varying in intensity in such manner as to throw the armature into that form of vibration which characterizes the given sound or

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like those of the membrane in the transmitting apparatus" (*Ibid.*, p. 34; **O.**, p. 1891.

"There is no doubt that the subject we have been considering * * * will require considerable improvement; it will especially be necessary to perfect the mechanism of the apparatus to be employed; * * *" (*Ibid.*, p. 35; **O.**, p. 1892).

"This also explains why chords and melodies were transmitted with marvellous accuracy in the practical experiments hitherto made, while single words in reading, speaking, etc., were less distinctly recognizable, although even in these the inflections of the voice, as in interrogation, exclamation, surprise, calling, etc., were clearly reproduced" (*Ibid.*, p. 35; **O.**, p. 1892).

"With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the tones of various instruments, and even to a certain extent, the human voice (*Ibid.*, p. 15; **O.**, p. 1870).

"Hitherto it has not been possible to reproduce the tones of human speech with a distinctness sufficient for every one" (*Ibid.*, p. 15; **O.**, p. 1870).

BELL.

sounds" (Specification of British Patent. No. 4765, Mol. R., p. 1472).

"It is a mistake, however, to suppose that the articulation was by any means perfect, * * * still the articulation was there, and I recognized the fact that the indistinctness was entirely due to the imperfection of the instrument" (**O.** pp. 2744–5).

"The effects were not sufficiently distinct to admit of sustained conversation through the wire. Indeed, as a general rule, the articulation was unintelligible, excepting when familiar sentences were employed" (**O.**, p. 3456).

"Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by means of the human voice or by means of a musical instrument" (Specification of U. S. Patent No. 174,465, Dowd. Rec., p. 56; **O.**, p. 3508).

"The results, however, were unsatisfactory and discouraging. Mr. Thos. A. Watson, who assisted me in this first experiment declared that he heard a faint sound proceed from the telephone at his end of the circuit, but I was unable to verify his assertion. After many experiments, attended with the same only partially successful results" (Mol. R., p. 2013; **O.**, p. 2744).

REIS.

"The pitch of the tone produced in this way depends upon the number of vibrations in a given time, but the character of the tone upon the number of swellings in the same time. Two vowels having the same pitch would differ in about the way represented by the curves (Fig. 1, 2), while the same tone without any vowel character would be represented by the curve (Fig. 3) (*Ibid.*, p. 18; **O.,** p. 1873).

"My apparatus reproduces the number of vibrations, but with an intensity much less than that of the original ones, though, as I have reason to believe, to a certain degree proportional among themselves" (*Ibid.*, p. 18; **O.,** p. 1873).

"Whether or not my views as to the curves corresponding to sound combinations are correct could be, perhaps, decided by means of the new phonautograph of Duhamel" ("Vierordt Physiology," p. 254) (*Ibid.*, p. 18; **O.,** p. 1873).

BELL.

"Hence, the co-existence upon a telegraphic circuit of electrical vibrations of different pitch is manifested not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations" (Dowd Rec., p. 53; **O.,** p. 3505).

"I had had the idea that magneto-electric currents generated by the vibration of permanent magnets or reeds would be too feeble to produce any useful, practical results" Mol. Rec., p. 1611.

"For some time I carried on experiments with the manometric capsule of Koenig, and with the phonautograph of Leon Scott. * * * With this apparatus I succeeded in producing very beautiful tracings of the vibrations of the air for vowel sounds. * * * I was much struck with this improved form of apparatus, and it occurred to me that there was a remarkable likeness between the manner in which this piece of wood was vibrated by the membrane of the phonautograph and the manner in which the ossiculæ of the human ear were moved by the tympanic membrane. I determined, therefore, to construct a phonautograph modeled still more closely upon the mechanism of the human ear, * * *"

REIS.

"It may be that for the practical application of the telephone much remains to be done * * *" (*Ibid.*, p. 18; **O.**, p. 1873).

"But the office of the auditory nerve is to bring to our consciousness the vibrations of matter which have occurred in a given time, both as regards number and amplitude" (*Ibid.*, p. 13; **O.**, p. 1865).

BELL.

(Mol. R. 2010-11; **O.**, pp. 2741-2742).

"It consists in improvements in the construction of the instruments without change in the mode of operation" (Bell Int. Cases, p. 653).

"I told him that on passing an intermittent current of electricity through an empty helix of insulated copper wire a noise could be heard proceeding from the coil, similar to that heard from the telephone. He started up—said, 'Is that so?' Will you allow me, Mr. Bell, to repeat your experiments, and publish them to the world through the Smithsonian Institute, of course, giving you the credit of the discoveries?" (Mol. Rec., p. 1601.)

"Cross-Int. 191. Please describe a little more fully the telephone indicated in the passage referred to 'being a telephone from the rod of which silk threads may lead to a series of bodies, such as tuning forks, &c?'"

Ans. "I referred to the receiving instrument of Reis's telephone, consisting of a rod of iron about six inches in length, supported by its ends upon a sounding box, and placed in the interior of a helix of copper wire" (Dowd Rec., p. 510; **O.**, p. 3295.

"Before this time I had perfectly satisfied myself that the true and only method for the telegraphic transmission of vocal sounds involved as its fundamental element, an apparatus which should transmit ampli-

REIS.

"The iron wire no longer gives its longitudinal normal tone, but a tone whose pitch corresponds to the number of interruptions. (Unterbrechungen in a given time.) This is the same as saying that the *rod reproduces the tone* (Ton) *impressed upon the interrupter* (dem Unterbrechungs Apparat)" (*Ibid.*, p. 16; **O.,** p. 1871).

"According to the experiments of Willis, Helmholtz and others, vowel tones can be produced artifically, if the vibrations of one body are from time to time augmented by those of another, somewhat as follows" (*Ibid.*, p. 17; **O.,** p. 1872).

"In this essay we shall not deal with the electric current as to its capacity for operating telegraphic apparatus of whatever construction for the reproduction of *visible signs*, but of the application of this current to the production of *audible* signals, of *tones* (Tönen)." (*Ibid.*, p. 29; **O.,** p. 1884).

"The tone transmitter, Fig. 4 A, consists of a conical tube *a b*, about * * *" (R. B., . 32: **O.,** p. 1888).

BELL.

tude or intensity as well as pitch—for "quality," or timbre, or articulation were ultimately resolvable into these two characteristics of vibration, &c., to be transmitted" (Mol. Rec., p. 2158).

"He then proceeds to describe an experiment whereby he made the discovery that when the intermittent or interrupted current from a circuit-breaker was passed through the coils of an electro-magnet, a sound was heard to proceed from the iron core, and the idea was suggested that an empty coil might produce a like effect. Although this may have been new to him, it had long previously been observed and commented upon by others" (Examiners' Decision, p. 277).

"Immediately after the conversation with Mr. Ellis, in 1867, I formed the resolution of reproducing Helmholtz's synthetical experiments. * * *" (Dowd Rec., Vol. 1, 442: **O.,** 3227).

"Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument" (Dowd Rec., Vol. II., p. 7; **O.,** 3428).

"E represents a speaking tube, by which sounds may be conveyed to or from the plate A" (Dowd Rec., Vol. II., p 11; **O.,** 3434).

REIS.

"The lever *i* with the armature is suspended from the standard *k* in the manner of a pendulum, its motion being regulated by means of the screw *l* and the spring *q*" (*Ibid.*, p. 34; **O.,** p. 1891).

"In order to increase the effect of the apparatus, the tone receiver may be placed at one of the focal points of an elliptically arched chamber of suitable size, and the listener may place his ear at the other focus of this chamber" (*Ibid.*, p. 34; **O.,** p. 1891).

"A friendly communication was sent us some time ago by Mr. J. F. Quilling, of Frankfurt-a-M., according to which the capacity of the apparatus to transmit tones to a considerable distance clearly and with their characteristic timbre (Klangfarbe) is fully established" (*Ibid.*, p. 38; **O.,** p. 1895).

"M. Beatson and M. de La Rive observed also that an intermittent current passed through a stretched wire made it produce (rendu) a sound identical with that which it would give forth if it were placed in the interior of a helix" (*Ibid.*, p. 63; **O.** p. 1920).

VARLEY'S PATENT.

"The wave signal receiving instrument * * * consists of an iron frame containing a sounding board *a* over bridges, at the end of which a hard drawn iron or steel wire *b* is stretched * * and is strained so as to

BELL.

"I is an adjusting screw, whereby the distance of the end H from the plate A may be regulated" (Dowd Rec., Vol. II., p. 11; **O.,** p. 3434).

"When * * *, it will be advisable for the operator to listen to his telephone through a resonator, which will re-enforce to his ear the signals which he desires to observe" (Dowd Rec., pp. 11-12; **O.,** p. 3434-5).

"3. The phono-telegraph, whereby the exact pitch, loudness and timbre of vocal or other sounds can be transmitted telegraphically, by causing electrical undulations upon the wire, similar in form to the aerial vibrations accompanying said vocal or other sounds" (Mol. R., p. 1622).

"The deduction I had made from the experiments was, that an intermittent current of electricity creates a molecular vibration in the conductor through which it had passed. * * * I shall carry a wire from my study into his room to-morrow, and try the effect of passing an intermittent current through the strings of a piano. Unless I am greatly mistaken, the string, whose rate of movement coincides with the molecular vibration induced in the wires by one of my transmitters, will resound loudly" (Dowd Rec., Vol. I., p. 464; **O.,** p. 3249).

REIS.

sound the same note as the tuning fork of the sending instrument" (Dowd Ca., Vol. II., p. 557; **O.,** p. 3650).

"In 1837 Mr. Page observed, for the first time, the phenomenon of the production of sound by electricity, when the poles of a magnet were rapidly brought near to and moved away from a helix of iusulated conducting wire through which an electrical current was passing. M. Delezenne produced an analogous effect by turning an armature of soft iron before the poles of a magnet" (*Ibid.*, p. 62; **O.,** p. 1919).

BELL.

"Don't you think it would be well to take out a *Caveat* for the use of the magneto-electric current?" (Dowd Rec., p. 483. O., 3268).

Sheet 1-2 Sheets.

C. F. Varley.

Telegraph.

No. 78,495. Patented Jun. 2, 1868.

Fig. 1.

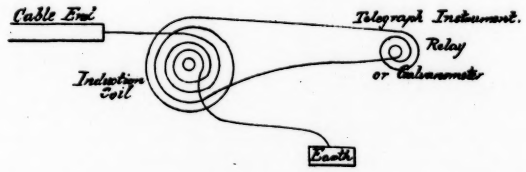


Fig. 2.

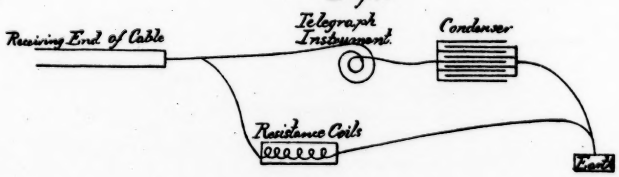


Fig. 3.

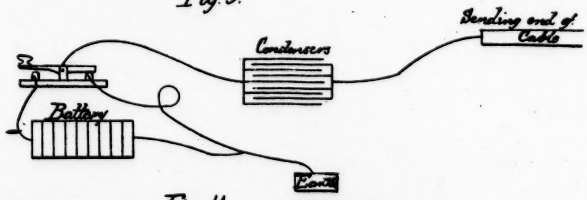
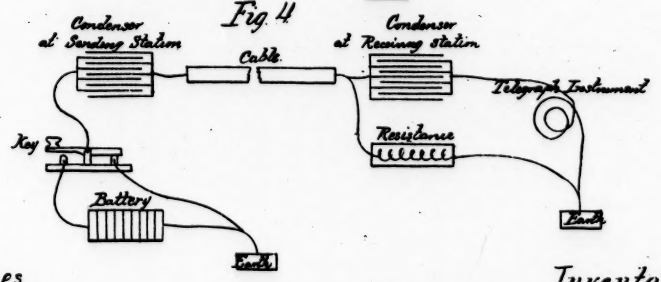


Fig. 4



Witnesses.
M. Bach
J. Page Jr.

Inventor.
Cromwell Fleetwood Varley
by his attorney

Sheet 2-2 Sheets.

C. F. Varley.

Telegraph.

No. 78,495. Patented Jun. 2, 1868.

Fig. 5.

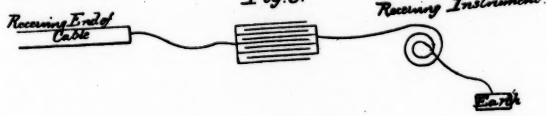


Fig. 1

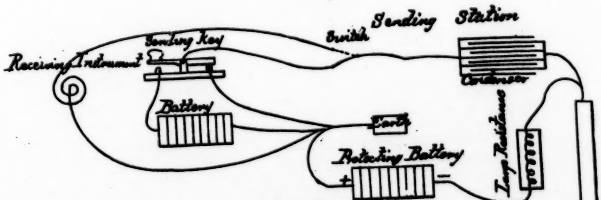


Fig. 6

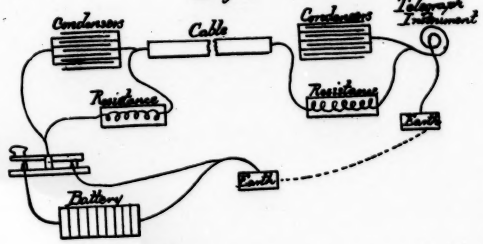
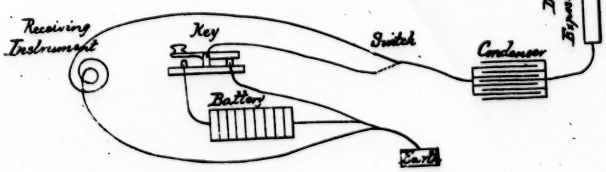


Fig. 7.

Receiving Station



Witnesses

M Brady

Inventor

Cromwell Fleetwood Varley
by his attorney

SHEET 2
4 SHEETS.

A.D. 1870, APRIL 8, N° 1044.
WARLEY'S SPECIFICATION.

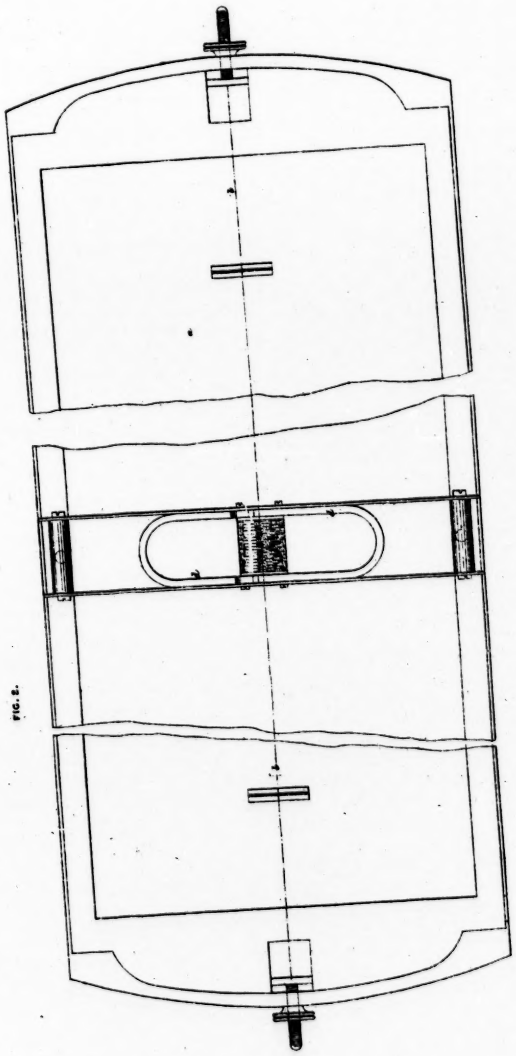
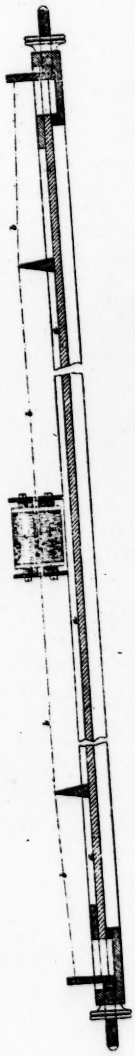


FIG. 2.



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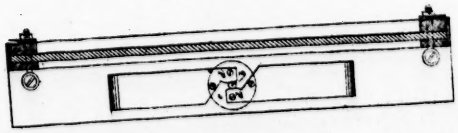


FIG. 4.

A.D. 1870, April 8. N° 1044.
VARLEY'S SPECIFICATION.

FIG. 5.

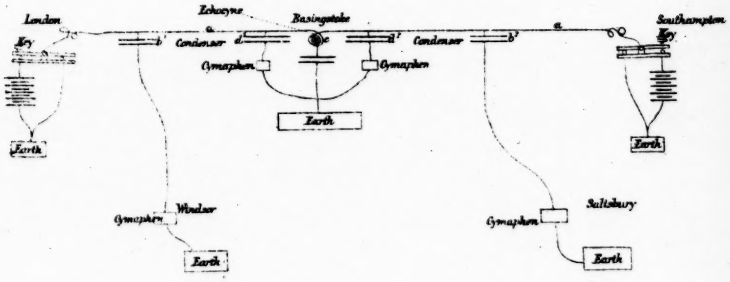
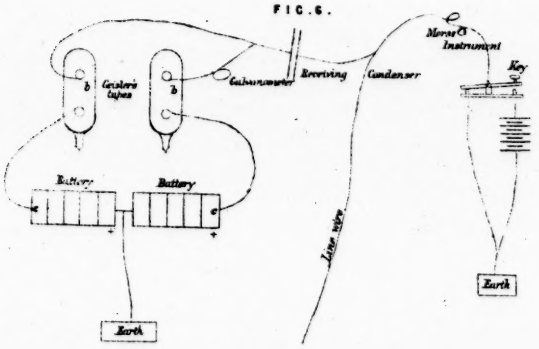


FIG. 6.



SHEET 4.
4 SHEETS.

A.D. 1870. APRIL 8. N° 1044.
VARLEY'S SPECIFICATION.

FIG. 7.

FIG. 8.

(Model.) 2 Sheets—Sheet 1.

A. E. DOLBEAR.

Apparatus for Transmitting Sound by Electricity.

No. 239,742. **Patented April 5, 1881.**

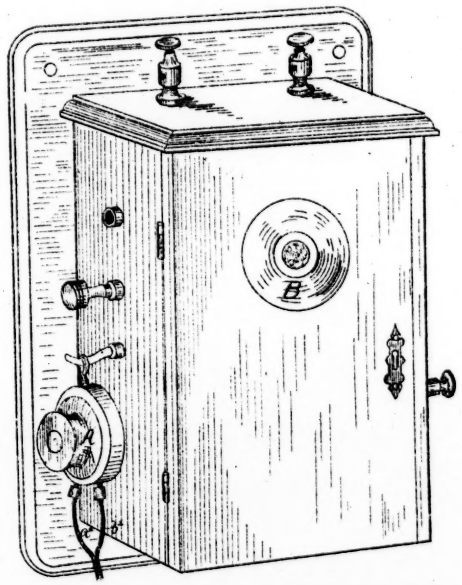


Fig. 1.

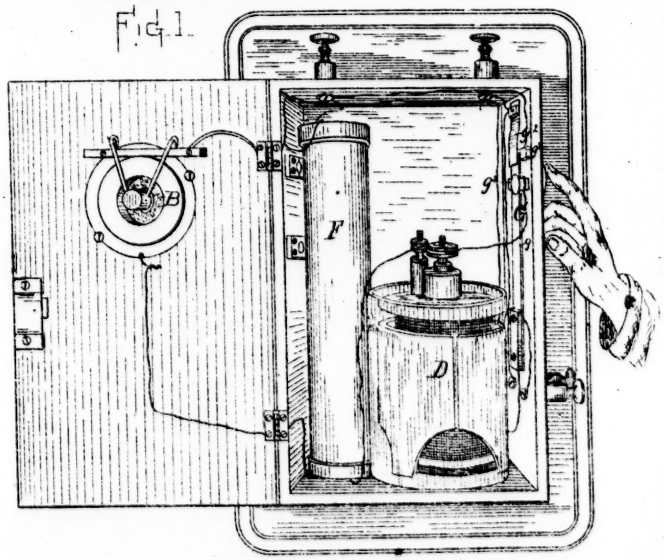


Fig. 2.

Witnesses:
Wm. Littell
John. R. Brown

Inventor:
Amos E. Dolbear
by J. S. Maynadier
his Atty.

(Model.) 2 Sheets—Sheet 2.

A. E. DOLBEAR.

Apparatus for Transmitting Sound by Electricity.

No. 239,742. **Patented April 5, 1881.**

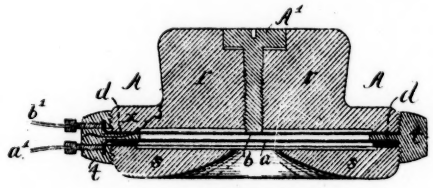


Fig. 3.

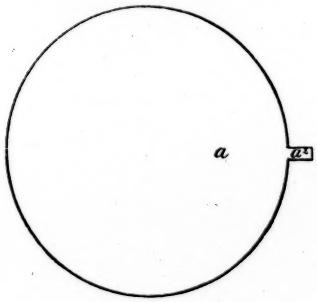


Fig. 4.

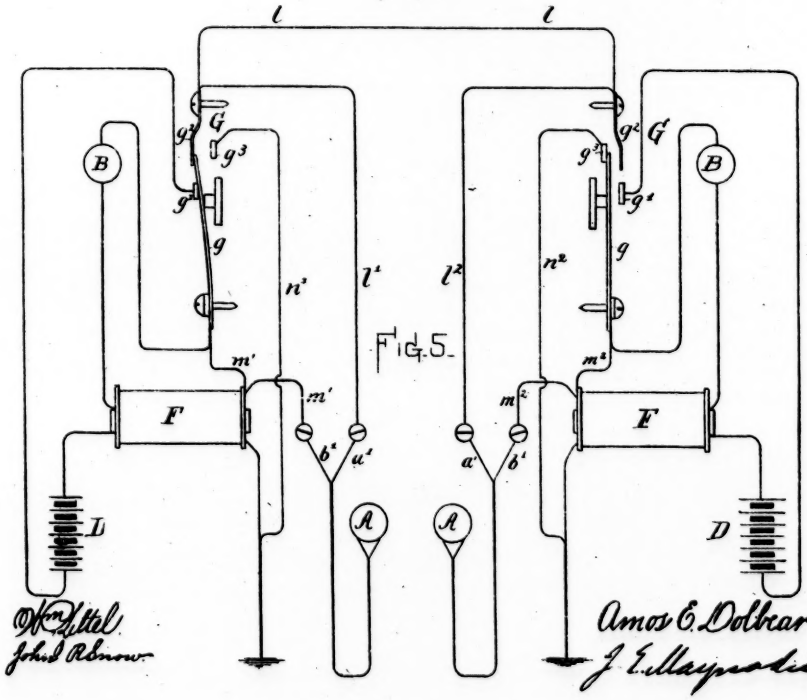


Fig. 5.

Wm. Littel
John R. Brown

Amos E. Dolbear
J. E. Mayperdier

(No Model.) 2 Sheets—Sheet 1.

H. CLAY.

TELEPHONIC TRANSMITTER.

No. 298,286. Patented May 6, 1884.

Fig. 1.

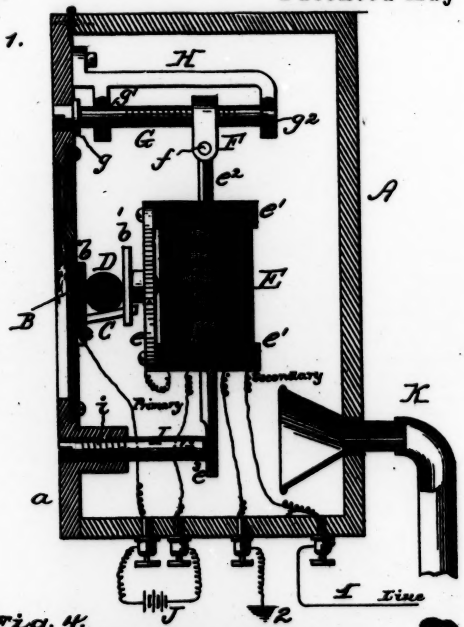


Fig. 4.

Fig. 2.

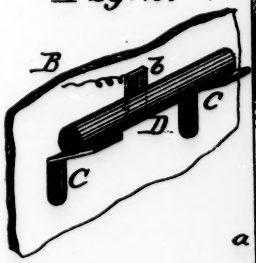
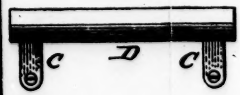


Fig. 3.



Attest:
A. M. Long
C. W. Williams

Inventor
Henry Clay
By S. G. VanSteenburg
Atty.

93

(No Model.) 2 Sheets—Sheet 2.

H. CLAY.

TELEPHONIC TRANSMITTER.

No. 298,286. Patented May 6, 1884.

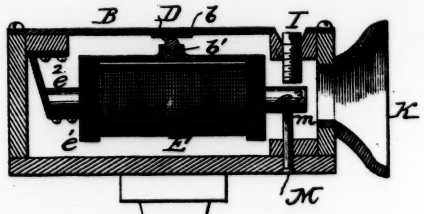
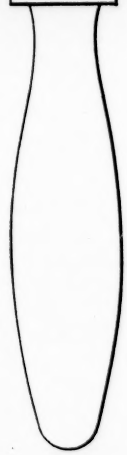


Fig. 5.



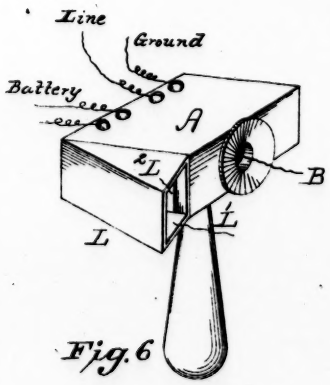


Fig. 6

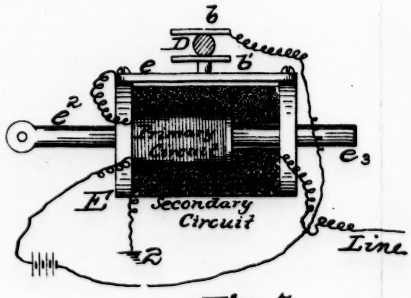


Fig. 7

Attest:
A. M. Long.
C. W. Williams

Inventor.
Henry Clay
By S. J. Van Stavoren
Att'y.

(No Model.)

95

H. CLAY.

TELEPHONE.

No. 277,112. Patented May 8, 1883.

Fig. 1.

Fig. 2.

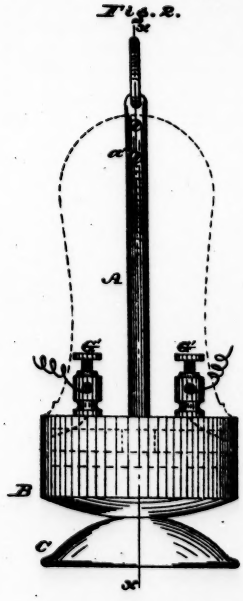


Fig. 3.

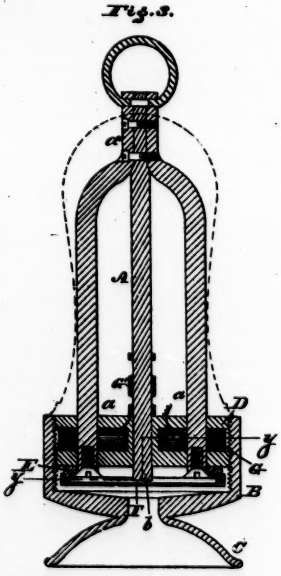
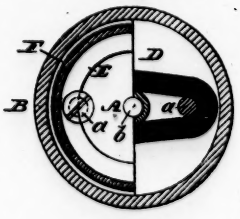


Fig. 4.



WITNESSES:

A. P. Grant,

W. F. Kircher

INVENTOR:

Henry Clay,

BY John A. Diedersheim

ATTORNEY.

A D. 1876. Dec. 9. N° 4765.
MORGAN-BROWN'S Specification

(3 SHEETS)
SHEET 1.

FIG. 1.

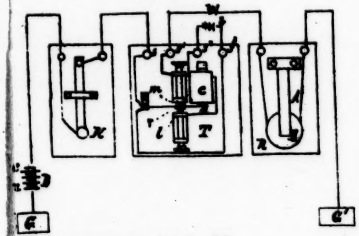


FIG. 2.

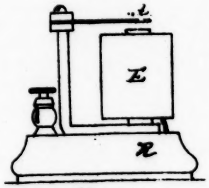


FIG. 27.

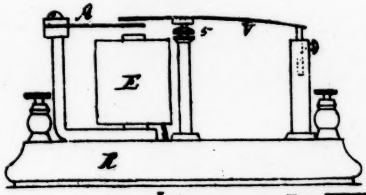


FIG. 20.

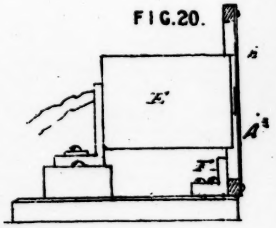


FIG. 28.

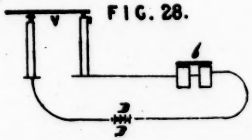


FIG. 29.

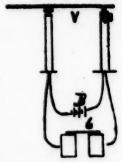
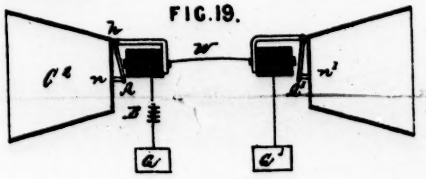


FIG. 15.

FIG. 19.



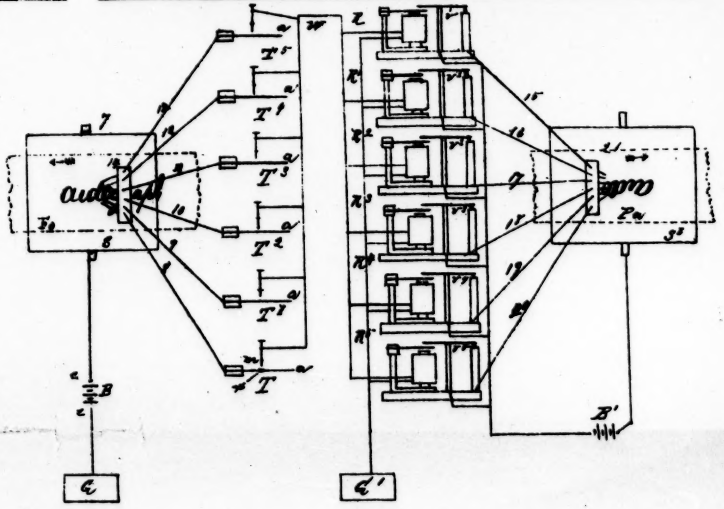


FIG. 6.
Direct

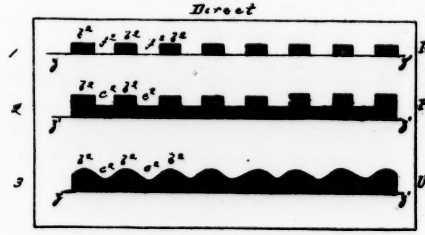


FIG. 7.
Reversed

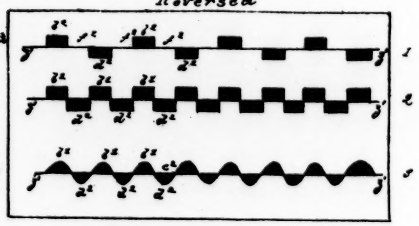


FIG. 11.

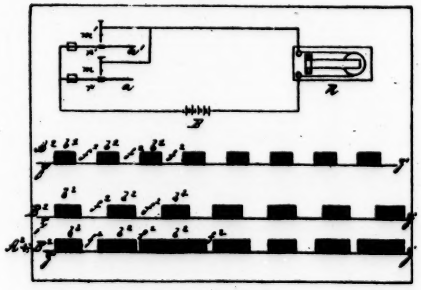


FIG. 12.

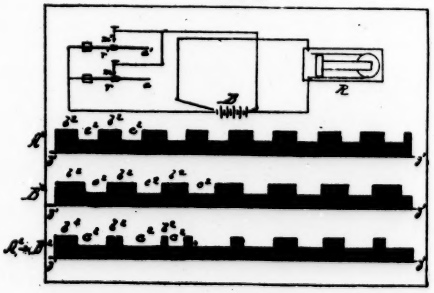


FIG. 13.

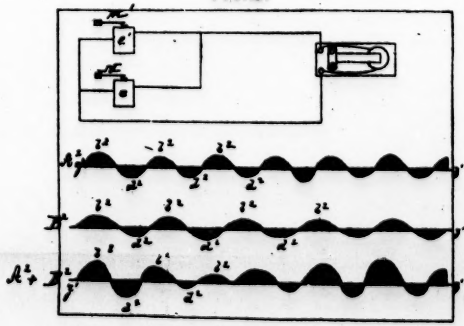
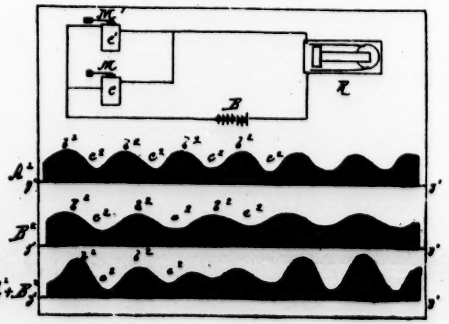


FIG. 14.



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MORGAN-BROWN'S Specification.

(3 SHEETS)
SHEET 2.

First Plan.

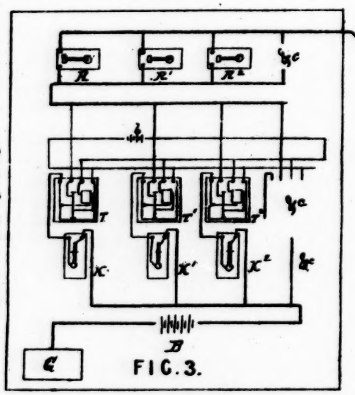


FIG. 3.

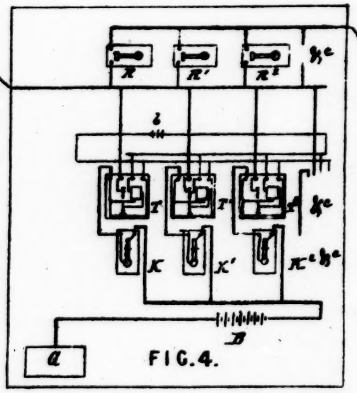


FIG. 4.

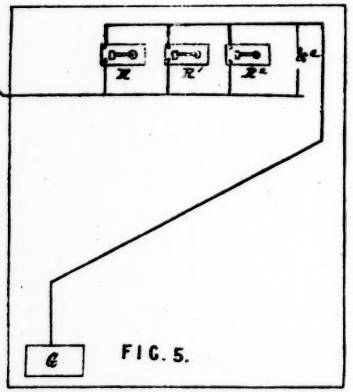


FIG. 5.

Second Plan.

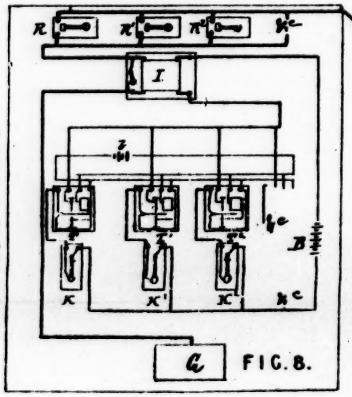


FIG. 8.

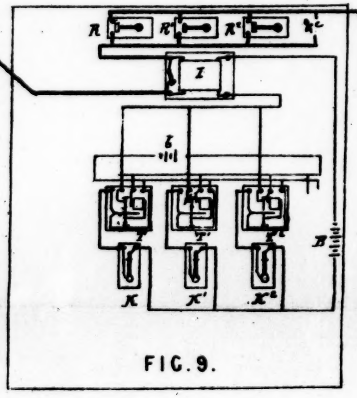


FIG. 9.

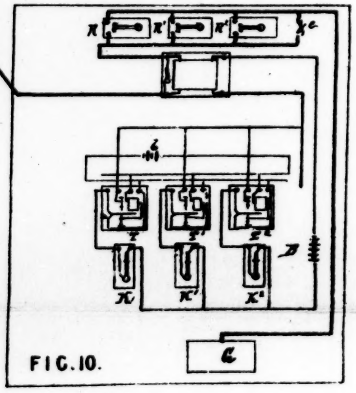
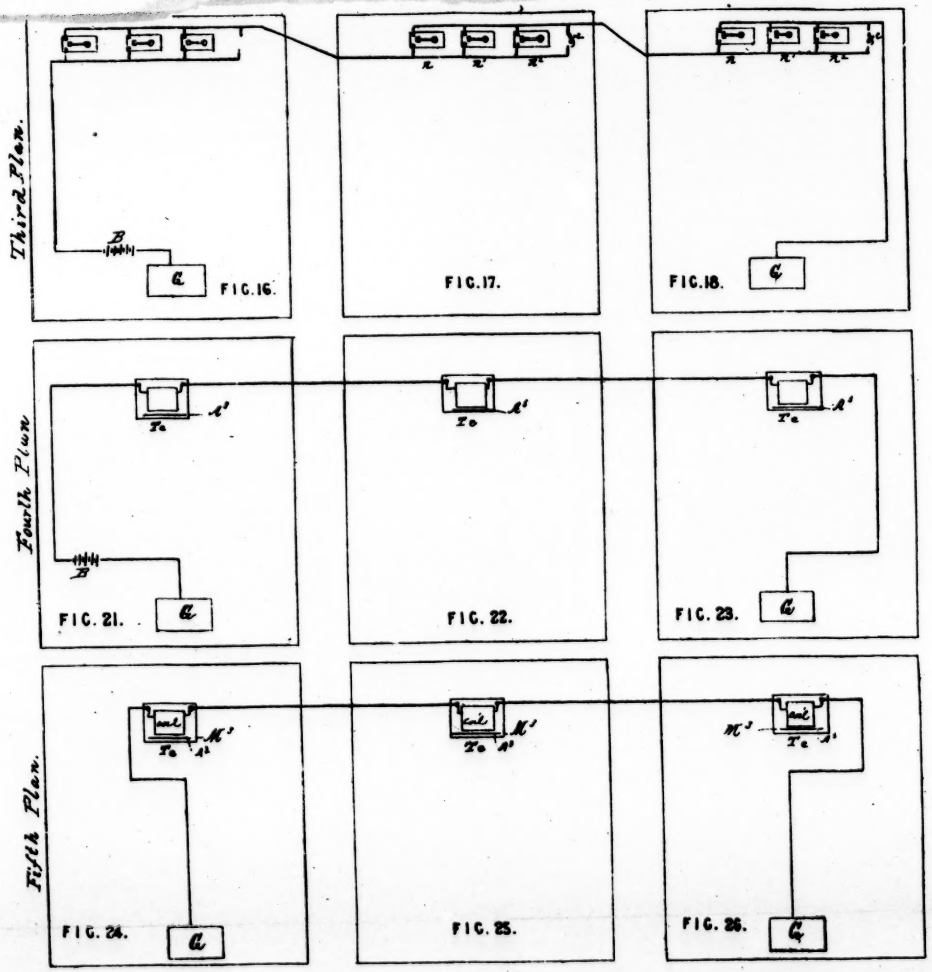


FIG. 10.


Third Flow.
FIG. 16.
FIG. 17.
FIG. 18.
Fourth Flow
FIG. 21.
FIG. 22.
FIG. 23.
Fifth Flow.
FIG. 24.
FIG. 25.
FIG. 26.

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(3 SHEETS)
SHEET 3.

FIG. 32.

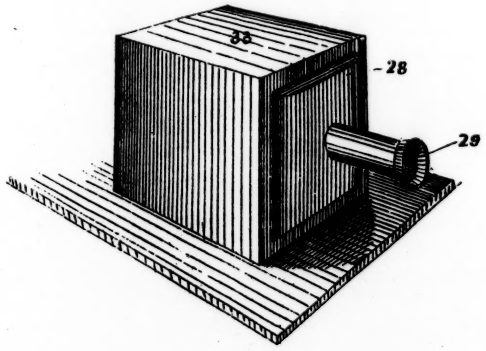
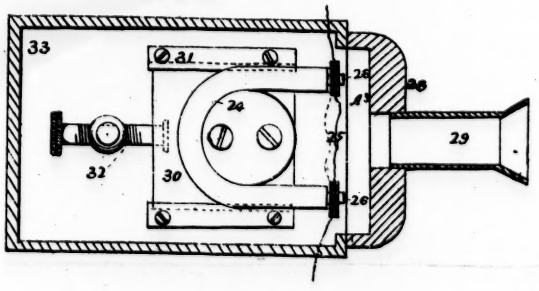


FIG. 31.



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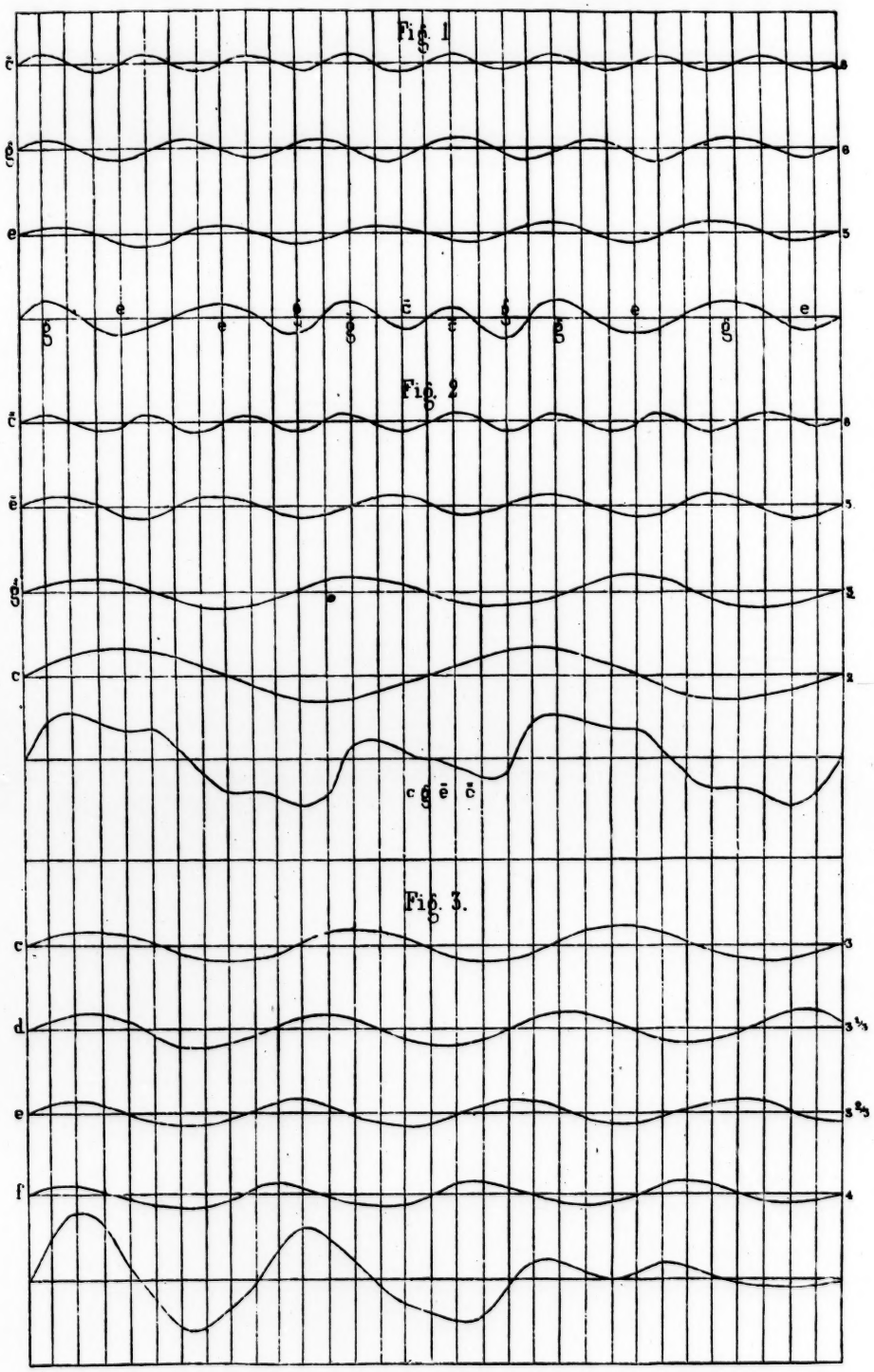
Printers to the Queen's most Excellent Majesty. 1876.

v. Legat, Reproduction von Tönen auf elektro galvanischem Wege



Ernst & Korn Berlin.